Next Generation Science Standards (NGSS) Cluster/Item Specifications

Specifications for Middle School

Introduction

This document presents *cluster specifications* for use with the Next Generation Science Standards (NGSS). These standards are based on the Framework for K-12 Science Education. The present document is not intended to replace the standards, but rather to present guidelines for the development of items and item clusters used to measure those standards.

The remainder of this section provides a very brief introduction to the standards and the framework, an overview of the design and intent of the item clusters, and a description of the cluster specifications that follow. The bulk of the document is composed of cluster specifications, organized by grade and standard.

Background on the framework and standards

The Framework for K-12 Science Education are organized around three core dimensions of scientific understanding. The standards are derived from these same dimensions:

- Disciplinary Core Ideas: The fundamental ideas that are necessary for understanding a given science discipline. The core ideas all have broad importance within or across science or engineering disciplines, provide a key tool for understanding or investigating complex ideas and solving problems, relate to societal or personal concerns, and can be taught over multiple grade levels at progressive levels of depth and complexity.

- Science and Engineering Practices: The practices are what students DO to make sense of phenomena. They are both a set of skills and a set of knowledge to be internalized. The SEPs reflect the major practices that scientists and engineers use to investigate the world and design and build systems.

- Cross-Cutting Concepts: These are concepts that hold true across the natural and engineered world. Students can use them to make connections across seemingly disparate disciplines or situations, connect new learning to prior experiences, and more deeply engage with material across the other dimensions. The NGSS requires that students explicitly use their understanding of the CCCs to make sense of phenomena or solve problems.

- There is substantial overlap between and among the three dimensions. For example, the cross-cutting concepts are echoed in many of the disciplinary core ideas. The core ideas are often closely intertwined with the practices. This overlap reflects the nature of science itself. For example, we often come to understand and communicate causal relationships by employing models to make sense of observations. Even within a dimension, overlap exists. Quantifying characteristics of phenomena is important in developing an understanding of them, so employing computational and mathematical thinking in the construction and use of models is a very common scientific practice, and one of the cross-cutting concepts suggests that scientists often infer causality by observing patterns. In short, the dimensions are not orthogonal.

The framework envisions effective science education as occurring at the intersection of these interwoven dimensions: students learn science by doing science—applying the practices through the lens of the cross-cutting concepts to investigate phenomena that relate to the content of the disciplinary core ideas.

Item clusters

Each item cluster is designed to engage the examinee in a grade-appropriate, meaningful scientific activity aligned to a specific standard.

Each cluster begins with a phenomenon, an observable fact or design problem that engages student interest and can be explained, modeled, investigated, or designed using the knowledge and skill described by the standard in question.

What it means to be observable varies across practices. For example, a phenomenon for a performance expectation exercising the a*nalyze data* practice may be observable through regularities in a data set, while standards related to the *development and use of models* might be something that can be watched, seen, felt, smelled, or heard.

What it means to be observable also varies across grade levels. For example, elementary-level phenomena are very concrete and directly observable. At the high school level, an observation of the natural world may be more abstract--for example, “observing” changes in the chemical composition of cells through the observation of macroscopic results of those changes on organism physiology, or through the measurement of system- or organ-level indications.

Content limits refine the intent of the performance expectations and provide limits on what may be asked of items in the cluster to structure the student activity. The content limits also reflect the disciplinary core ideas learning progressions that are present in the K-12 Framework for Science Education.

The task or goal should be explicitly stated in the stimulus or the first item in the cluster: statements such as "In the questions that follow, you will develop a model that will allow you to identify moons of Jupiter," or "In the questions below, you will complete a model to describe the processes that lead to the steam coming out of the teapot."

Whereas item clusters have been described elsewhere as "scaffolded," they are better described as providing structure to the task. For example, some clusters begin with students summarizing data to discover patterns that may have explanatory value. Depending on the grade level and nature of the standard, items may provide complete table shells or labeled graphs to be drawn, or may require the student to choose what to tabulate or graph. Subsequent items may ask the student to note patterns in the tabulated or graphed data and draw on domain content knowledge to posit explanations for the patterns.

These guidelines for clusters do not appear separately in the specifications. Rather, they apply to all clusters.

Structure of the cluster specifications

The item cluster specifications are designed to guide the work of item writers and the review of item clusters by stakeholders.

Each item cluster has the following elements:

- The text of the performance expectations, including the practice, core idea, and cross-cutting concept.
- Content limits, which refine the intent of the performance expectations and provide limits of what may be asked of examinees. For example, they may identify the specific formulae that students are expected to know or not know.
- Vocabulary, which identifies the relevant technical words that students are expected to know, and related words that they are explicitly not expected to know. Of course, the latter category should not be considered exhaustive, since the boundaries of relevance are ambiguous, and the list is limited by the imagination of the writers.
- Sample phenomena, which provide some examples of the sort of phenomena that would support effective item clusters related to the standard in question. In general, these should be guideposts, and item writers should seek comparable phenomena, rather than drawing on those within the documents. Novelty is valued when applying scientific practices.
- Task demands comprise the heart of the specifications. These statements identify the types of items and activities that item writers should use, and each item written should be clearly linked to one or more of the demands. The verbs in the demands (e.g., *select, identify, illustrate, describe*) provide guidance on the types of interactions that item writers might employ to elicit the student response. We avoid explicitly identifying interaction types or item formats to accommodate future innovations and to avoid discouraging imaginative work by the item writers.
- For each cluster we present, the printed documentation includes the cluster, the task demands represented by each item, and its linkage to the practice and cross-cutting concept identified in the performance expectation.

Item cluster specifications follow, organized by domain and standard.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-1
Develop models to describe the atomic composition of simple molecules and extended structures.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and/or use a model to predict and/or describe phenomena.</td><td>PS1.A: Structure and Properties of Matter
• Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
• Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).</td><td>Scale, Proportion, and Quantity
• Time, space, and energy phenomena can be observed at various scales, using models to study systems that are too large or too small.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on identifying elements vs. compounds and their basic units of atoms and molecules.
• Emphasis is on developing models of molecules that vary in complexity.
• Examples of simple molecules could include ammonia, methanol, methane, water, carbon dioxide, etc.
• Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.
• Examples of extended structures could include sodium chloride or diamonds.

Content Limits
• Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.
• Modelling should be limited to molecules that have only one type of bond, no combination of bonds; the structure of the molecule is easy to model; single bonded molecules.
• Students are not expected to memorize the atomic characteristics of any element.
• <u>Students do not need to know</u>: valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, a complete description of all individual atoms in a complex molecule or extended structure, memorization of atoms found in different molecule, VSEPR or geometric arrangements, the difference between single, double, and triple bonding, periodic table patterns and how it affects bonding, oxidation numbers, polyatomic ions.</td></tr>
<tr><td colspan="4" align="center">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS1-1:
• Submarines can stay underwater for months using sea water as a source of oxygen for air. Special machines run electricity through large amounts of sea water, generating oxygen from the water.</td></tr>
</table>

	• Water and hydrogen peroxide are both made up of hydrogen and oxygen. When water is poured on a chunk of $CaCO_3$, there is no reaction. When hydrogen peroxide is poured on a chunk of $CaCO_3$, it fizzes. • Oxygen (O_2) is a gas we breathe to stay alive. Ozone (O_3), also made only of oxygen atoms, is unhealthy to breathe.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Identify or assemble from a collection of potential model components, including distractors, components of a model that describes the structures of atoms, molecules, or extended molecules and/or how they interact, or explains how atoms of the same or different element(s) are arranged in repeated patterns in extended structures.
2. Describe, select, and/or identify the relationships among components of a model that describes the structures of atoms, molecules, or extended molecules and/or how they interact, or explains how atoms of the same or different element(s) are arranged in repeated patterns in extended structures.
3. Assemble, illustrate, describe, and/or complete a model or manipulate components of a model to describe the structure of an atom, molecule, or extended molecule and/or how they interact, or to explain or predict how atoms of the same or different element(s) are arranged in repeated patterns in extended structures.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-2
Analyze and interpret data on the properties of substances before and after the substances interact to determine whether a chemical reaction has occurred.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to determine similarities and differences in findings.</td><td>PS1.A: Structure and Properties of Matter
• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: Chemical Reactions
• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</td><td>Patterns
• Macroscopic patterns are related to the nature of microscopic and atomic-level structure.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.

Content Limits
• Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.
• Students are not expected to balance chemical equations or to determine whether a chemical equation is balanced or not.
• Students are expected to know that mass/matter is neither destroyed nor created.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">For this performance expectation the phenomena are mixtures of substances that provide sets of data. Those are the observations and/or measurements concerning the physical and chemical properties of the involved substances before and after mixing that the kids will look at to discover patterns. Below, we enumerate some of the mixtures that might provide the data sets to be analyzed.

All phenomenon for this PE should be situations where a chemical reaction is not immediately apparent.

Some example phenomena for MS-PS1-2:
• Rainwater can produce stains on car paint. Reports of these stains are more common in the Southeastern U.S. than they are in the Midwest.
• Portions of marble statues that are exposed to rainwater crack and crumble over time. Portions of marble statues that are sheltered develop a black coating over time.</td></tr>
</table>

	• When sugar crystals are added to vinegar in a bowl, the crystals disappear. When crystals of table salt are added to vinegar in a bowl, the mixture begins to bubble and foam. • Table sugar exposed to an open flame transforms into a gooey, dark substance. Wood exposed to an open flame transforms into ash.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Organize, arrange, and/or generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations among observations and data concerning the physical and chemical properties of the substances involved. This may include sorting out distractors.
2. Describe and/or summarize data (e.g., using illustrations and/or labels), to identify/highlight trends, patterns, or correlations among observations and data concerning the physical and chemical properties of the beginning and ending substances being investigated.*
3. Use relationships identified in the data to predict whether the mixing of substances similar to the ones under study will result in the occurrence of a chemical reaction.
4. Identify patterns or evidence in the data that support inferences about any changes that occurred in the microscopic or atomic-level arrangements of the substances involved.*

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-3
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.</td></tr>
<tr><td>Dimensions</td><td>Obtaining, Evaluating, and Communicating Information
• Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.</td><td>PS1.A: Structure and Properties of Matter
• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: Chemical Reactions
• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</td><td>Structure and Function
• Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on natural resources that undergo a chemical process to form the synthetic material.
• Examples of new materials could include new medicine, foods, building materials, plastics and alternative fuels

Content Limits
• Assessment is limited to qualitative information.
• Students are not required to know particular names for synthetic materials (i.e. rayon, polyester, acrylic, nylon, rayon, acetate, orlon, Kevlar)
• <u>Students do not need to know</u>: the types of reaction mechanisms involved in chemical reactions such as polymerization.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS1-3:
• It is difficult for the naked eye to tell the difference between cubic zirconia (CZ) and diamond, but a genuine diamond will give off a strong blue fluorescence when held under U.V. light.
• Naturally occurring penicillin from penicillium mold is an effective antibiotic against infections, but it is broken up by stomach acid and can only be injected into the bloodstream.
• The bark of the white willow tree can be used as an alternative to aspirin for pain relief.
• Nylon and Kevlar are both synthetic fabrics, but Kevlar is much stronger – about five times as strong as steel.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Analyze and interpret scientific evidence from multiple scientific/technical sources including text, diagrams, charts, symbols and mathematical representations to describe how synthetic materials are made and how they come from natural resources.*
2. Based on the information provided, identify, describe or illustrate a claim regarding the relationship between a characteristic of a synthetic material and its function in real world applications.
3. Identify, summarize, or organize given data or other information to support or refute a claim that relates characteristic of a synthetic material to its function in real world.
4. Identify relationships or patterns in scientific evidence at macroscopic and/or microscopic scales.
5. Synthesize an explanation that incorporates the scientific evidence from multiple sources.
6. Using scientific evidence, evaluate the validity/relevance/reliability of using synthetic materials as alternatives to natural materials and/or their impact on society.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

**For stand-alone items, focus on charts, diagrams, etc. rather than text-heavy stems for time considerations.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop a model to predict and/or describe phenomena.</td><td>PS1.A: Structure and Properties of Matter
• Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
• In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

PS3.A: Definitions of Energy
• The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary)
• The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material (secondary).</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs.
• Examples of models could include drawings and diagrams.
• Examples of particles could include molecules of inert atoms.
• Examples of pure substances could include water, carbon dioxide, and helium.

Content Limits:
• Physical changes should be limited to freezing, melting, condensation, and evaporation.
• Assessment does not include:
    o Sublimation (solid change of state directly to a gas);
    o Calculations for internal energy, transfer of heat (q), (system and surroundings), entropy, work, and Hess’s law;
    o Ideal gas laws and their relationships (Boyle’s, Charles, Combined, PV=nRT, etc.);
    o The role that pressure and force (N) have in the kinetic molecular theory;
    o Energy needed to break and reform chemical bonds in a chemical reaction, including the use of a catalyst to speed up a reaction;
    o Absolute zero and kelvin (Celsius and Fahrenheit temperature only).
• <u>Students do not need to know</u>:
    o Atomic structure (electrons orbit around a nucleus containing protons and neutrons)</td></tr>
</table>

	○ The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. ○ Stable forms of matter are those in which the electric and magnetic field energy is minimized. ○ A stable molecule has less energy, by an amount known as the binding energy, than the same set of atoms separated; one must provide at least this energy in order to break the bonds of a molecule. ○ That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and among its various possible forms.
Phenomena	
Context/ Phenomena	Some example phenomena for MS-PS1-4: • A tea kettle is sitting on a stove, under heat. As the water in the kettle begins to boil, a stream of steam is visible outside of its spout. • Dew forms on the grass in the morning. • As sugar is heated in a pan, it turns from a white solid to a light brown liquid.
This Performance Expectation and associated Evidence Statements support the following Task Demands.	
Task Demands	
1. Select or identify from a collection of potential model components, including distractors, the components needed to model of the model changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Components might include: energy source, particles in motion, and boundaries of system.	
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. This <u>does not</u> include labeling an existing diagram.	
3. Manipulate the components of the model to demonstrate the changes, properties, processes, and/or events that act to result in the changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.*	
4. Make predictions about the effects of changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.*	
5. Given models or diagrams of particle motion, temperature, and state of a pure substance when thermal energy is added or removed, identify how they change over time in a given scenario OR identify the properties of the variables that cause the changes.	
6. Identify missing components, relationships or other limitations of the model.	
7. Describe, select, or identify the relationships among components of a model that describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	

*denotes those task demands which are deemed appropriate for use in stand-alone item development

**TD4 must be used with TD3 (…by completing illustrations…etc. is what makes this need to be paired)

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-5
Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe unobservable mechanisms.</td><td>PS1.B: Chemical Reactions
• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
• The total number of each type of atoms is conserved and thus the mass does not change.</td><td>Energy and Matter
• Matter is conserved because atoms are conserved in physical and chemical processes.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasize demonstrations of an understanding of the law of conservation of matter.
• Emphasis is on law of conservation of matter and on physical models or drawings, including digital formats that represent atoms.
• Models can include already balanced chemical equations.

Content Limits
• Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.
• Assessment does not include stoichiometry or balancing equations.
• Assessment is limited to simpler molecules, i.e., carbon dioxide, ammonia, sodium chloride, methanol, calcium chloride.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS1-5:
• An antacid tablet was added to water and bubbles appeared. The mass of the water and antacid tablet after the tablet dissolved was less than the mass of the water and tablet before they were mixed.
• A strip of metal was added to acid in a test tube and a balloon was placed on top of the test tube. Bubbles appeared and after a few minutes, the balloon inflated.
• 100g of sugar completely dissolved in 100ml of water. After it dissolved, the mass of the mixture was 200g.
• Steel wool was soaked in water ad left out to dry. The steel wool turned dark red, ad the mass of the steel wool after it dried was greater than before it was soaked in the water.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Select or identify from a collection of potential model components, including distractors, the components needed to model the phenomenon. Components might include atoms and molecules.</td></tr>
</table>

2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing the conservation of matter.*
3. Manipulate the components of the model to demonstrate the changes, properties, processes, and/or events that act to result in the phenomenon.*
4. Make predictions about the effects of changes in chemical reactions. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.**
5. Identify missing components, relationships, or limitations of the model.
6. Describe, select, or identify the relationships among components of a model that describe the conservation of matter, or explain the chemical reaction.
7. Use the model to provide a causal account that matter is conserved during a chemical reaction by calculating the number of atoms or total mass of reactants and products.

*denotes those task demands which are deemed appropriate for use in stand-alone item development
**TD4 may only be used in conjunction TD3

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-6
Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.</td><td>PS1.B: Chemical Reactions
• Some chemical reactions release energy, others store energy

ETS1.B: Developing Possible Solutions
• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary)

ETS1.C: Optimizing the Design Solution
• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary)</td><td>Energy and Matter
• The transfer of energy can be tracked as energy flows through a designed or natural system.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance.
• Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.

Content Limits
• Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.
• <u>Students do not need to know:</u>
o Types of chemical reactions (decomposition, synthesis, single replacement, double replacement, combustion, etc.)
o How to balance a chemical equation</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Engineering performance expecations are built around meaningful design problems rather than phenomena. For this performance expectation, the design problem and solutions replace phenomena.</td></tr>
</table>

	Some example design problems for MS-PS1-6: • Design a sport's injury pack that when used, will heat and soothe sore muscles. • Design a sport's injury cold pack that will help prevent swelling. • Design a self-heating pad that can warm ready-to-eat meals. • Design a device that can be used to keep electronics, like computers, from overheating.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.
2. Express or complete a causal chain explaining the chemical processes that resulted in the release or absorption of thermal energy. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
3. Describe, identify, and/or select evidence supporting the inference of causation that is expressed in a causal chain and/or an explanation of the processes that cause the observed results.
4. Use an explanation to predict the direction or the relative magnitude of a change in thermal energy of a chemical system, given a change in the amount/concentration of chemical substances in the system, the temperature of the substances in the system, and/or the amount of time the substances interact in the system.
5. Identify or assemble from a collection, including distractors, the relevant aspects of the problem that given design solutions, if implemented, will resolve/improve.
6. Using the given information, select or identify the criteria against which the device or solution should be judged.
7. Using given data, propose, illustrate, or assemble a potential device (prototype) or solution.
8. Using a simulator, test a proposed prototype and evaluate the outcomes, potentially including proposing and testing modifications to the prototype.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS2-1
Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Apply scientific ideas or principles to design an object, tool, process, or system.</td><td>PS2.A: Forces and Motion
• For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s Third Law).</td><td>Systems and System Models
• Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.

Content Limits
• Assessment is limited to vertical or horizontal interactions in one dimension.
• <u>Students do not need to know</u>: vector addition</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Engineering performance expectations are built around meaningful design problems rather than phenomena. In this case, the design problems involve two colliding objects in a system. For this performance expectation, the design problem and competing solutions replace phenomena.

Some example design problems for MS-PS2-1:
• Testing different balls/objects for elementary students to throw at a dunk-tank target.
• Design a bike helmet that will keep the rider safe during a collision.
• Design a container that will protect vaccines from breaking as they are transported across rough terrain.
• Use Newton’s third law to create a system that will allow a ball to bounce higher than the height from which it was dropped.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Identify or assemble from a collection, including distractors, the relevant aspects of the problem that given design solutions, if implemented, will resolve/improve.</td></tr>
<tr><td colspan="4">2. Using given information, select or identify constraints that the device or solution must meet, including cost, mass, and speed of objects and materials.</td></tr>
<tr><td colspan="4">3. Using the given information, select or identify the criteria against which the device or solution should be judged.</td></tr>
</table>

4. Using given data, propose/illustrate/assemble a potential device (prototype) or solution.*
5. Using a simulator, test a proposed prototype and evaluate the outcomes; potentially propose and test modifications to the prototype.*

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS2-2
Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.</td></tr>
<tr><td>Dimensions</td><td>Planning and Carrying Out Investigations
• Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim</td><td>PS2.A: Forces and Motion
• The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
• All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.</td><td>Stability and Change
• Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on:
  o Balanced (Newton’s First law) and unbalanced forces in a system
  o Qualitative comparisons of forces, masses and changes in motion (Newton’s Second Law)
  o Frame of reference and specification of units

Content Limits
• Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time.
• <u>Students do not need to know:</u> trigonometry</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS2-2:
• A tennis ball is dropped on a trampoline and bounces up to a height, h. A bowling ball is then dropped on the same trampoline. The bowling ball bounces up to a height higher than h.
• A bowling ball is rolled towards a bowling pin. When the bowling ball hits the pin, the pin falls down. Then, a marble is rolled towards a bowling pin. When the marble hits the pin, the pin does not fall down.
• A soccer player kicks the ball 50 yards. She then kicks another ball and it only goes 30 yards.</td></tr>
</table>

	• Two magnets of the same size are held apart from each other. One magnet is let go and moves towards the stationary magnet. When two other magnets are close to each other and one is let go, it moves toward the stationary magnet, faster.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Identify from a list, including distractors, the materials/tools needed for an investigation of how the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
2. Identify the outcome data that should be collected in an investigation of how the sum of the forces on an object, as well as the object's mass, affect the change in motion of the object.
3. Evaluate the sufficiency and limitations of data collected to explain the phenomenon.
4. Make and/or record observations about how the sum of the forces on an object, and the mass of the object, affect the change in motion of the object.
5. Interpret and/or communicate the data from an investigation on how the change in motion of an object is affected by the sum of all forces and the mass of the object.
6. Explain or describe the causal processes that lead to the data that is observed in an investigation of how the forces on an object, and its mass, affect its change in motion.
7. Select, describe, or illustrate a prediction made by applying the findings from an investigation on how the forces on an object, and its mass, affect its change in motion.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS2-3
Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces.</td></tr>
<tr><td>Dimensions</td><td>Asking Questions and Defining Problems
• Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.</td><td>PS2.B: Types of Interactions
• Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples could include electromagnets, electric motors, or generators.
• Examples of data could include the effect of the number or turns of wire on the strength of an electromagnet, or of increasing the number or strength of magnets on the speed of an electric motor.

Content Limits
• Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS2-3:
• A radio emits music from its speakers. After a magnet in the speakers is removed, no sound can be heard.
• More electrical current is produced by a windmill when the wind speed is greater.
• Merchandise from a store that uses electromagnetic anti-shoplifting devices will set off an alarm at the exit if the tag is not removed.
• An electromagnet at a junkyard can lift old cars, while a homemade electromagnet cannot pick up much more than a few paper clips.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Make and/or record observations about the factors that affect electromagnets, electric motors, or generators.</td></tr>
<tr><td colspan="4">2. Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations in the change in the strength of electrical and magnetic forces.</td></tr>
<tr><td colspan="4">3. Generate or construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations in the factors that affect the strength of electric and magnetic forces. This may include sorting out distractors.</td></tr>
</table>

4. Explain or describe the causal processes that lead to the change in the strength of electrical and magnetic forces.
5. Use relationships identified in the data to predict the strength of electric and/or magnetic forces.
6. Select from a list of questions, including distractors, a scientifically testable question about factors that affect the strength of electrical or magnetic forces.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS2-4
Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td><td>PS2.B Types of Interactions
• Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.</td><td>Systems and System Models
• Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of evidence of arguments could include data generated from simulations or digital tools, and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system.

Content Limits
• Assessment does not include Newton's law of gravitation or Kepler's laws.
• <u>Students do not need to know:</u> mathematical representations of gravity (values, units, etc.).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS2-4:
• The moon orbits Earth.
• Astronauts fall more slowly when jumping on the moon than on Earth.
• A dropped apple falls toward Earth, but not toward the moon.
• Rockets have to travel extremely fast when they leave Earth.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information.</td></tr>
<tr><td colspan="4">2. Predict outcomes when properties or proximity of the objects are changed, given the inferred cause and effect relationships</td></tr>
<tr><td colspan="4">3. Describe, identify, and/or select information needed to support an explanation.**</td></tr>
<tr><td colspan="4">4. Identify patterns or evidence in the data that support conclusions about the relationship between mass and gravity.*</td></tr>
</table>

5. Using evidence, explain the relationship between mass and gravity.*

*denotes those task demands which are deemed appropriate for use in stand-alone item development
**TD3 may be used only in conjunction with TD4 or TD5.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS2-5
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.</td></tr>
<tr><td>Dimensions</td><td>Planning and Carrying Out Investigations
• Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.</td><td>PS2.B: Types of Interactions
• Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls.
• Examples of investigations could include first-hand experiences or simulations.

Content Limits
• Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS2-5:
• A compass is opened and set on a table. The needle spins for a bit and then settles pointing north.
• Two blue-painted metal boxes sit on a table. With a pocket knife, a person easily scratches some of the paint off of one box. But they cannot remove the paint from the other box.
• A person walks across a carpeted floor in stocking feet. They touch another person who is sitting in a chair, delivering a large shock.
• A multimeter records the presence of an electric current when a coil rotates near a magnet.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Identify from a list, including distractors, the materials/tools/steps needed for an investigation of fields that exist between objects exerting forces on each other even though the objects are not in contact.</td></tr>
<tr><td colspan="4">2. Identify the outcome data that should be collected for a given purpose in an investigation of fields that exist between objects exerting forces on each other even though the objects are not in contact.</td></tr>
<tr><td colspan="4">3. Evaluate the sufficiency and limitations of data collected to explain the phenomenon.</td></tr>
</table>

4. Make and/or record observations about fields that exist between objects exerting forces on each other even though the objects are not in contact.
5. Interpret and/or communicate the data from an investigation of the field that exists between two objects exerting forces on each other even though the objects are not in contact.
6. Explain, describe, or identify the causal processes that lead to the observed data about the field that exists between two objects exerting forces on each other even though the objects are not in contact.
7. Select, describe, or illustrate a prediction made by applying the findings from an investigation of the field that exists between two objects exerting forces on each other even though the objects are not in contact

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS3-1
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Construct and interpret graphical displays of data to identify linear and nonlinear relationships</td><td>PS3.A: Definitions of Energy
• Motion energy is properly called kinetic energy it is proportional to the mass of the moving object and grows with the square of its speed.</td><td>Scale, Proportion, and Quantity
• Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed.
Examples could include:
Riding a bicycle at different speeds
Rolling different sizes of rocks downhill
Getting hit by a wiffle ball vs a tennis ball
Content Limits
<u>Students do not need to know:</u> vectors such as velocity, the exact formula for the kinetic energy of an object or how to make calculations using the formula.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS3-1:
Balls of different masses are dropped into a pile of snow. A graph of the mass vs. the depth of the indent is shown.
A pendulum is dropped so that it hits a box on the ground. A graph of the drop height vs the distance the box travels is shown.
A ball thrown at a wall will bounce back a certain distance. A table of the speed of the ball vs. the distance it bounces back is given.
Trains with differing amounts of train cars all come to a stop. A table of the number of train cars vs stopping distance is given.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations among observations and data concerning the mass, speed and kinetic energy of objects. This may include sorting out distractors.</td></tr>
<tr><td colspan="4">2. Generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations in how the kinetic energy of an object changes with its mass and its speed. This may include sorting out distractors.</td></tr>
</table>

3. Use relationships identified in the data to predict how the kinetic energy of an object will change based on a change in speed of the object or mass of the object.
4. Identify patterns or evidence in the data that supports inferences about how kinetic energy changes with the speed of an object and the mass of an object.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS3-2
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop a model to describe unobservable mechanisms.</td><td>PS3.A: Definitions of Energy
• A system of objects may also contain stored (potential) energy, depending on their relative positions.

PS3.C: Relationship Between Energy and Forces
• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.</td><td>Systems and System Models
• Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on relative amounts of potential energy, not on calculations of potential energy.
• Examples of objects within systems interacting at varying distances could include the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate’s hair.
• Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

Content Limits
• Assessment does not include calculations of kinetic and potential energy.
• Assessment is limited to two objects and electric, magnetic, and gravitational interactions.</td></tr>
<tr><td colspan="4">atPhenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS3-2:
• A roller coaster track contains two hills of equal size. A roller coaster car sitting on the first hill is released and allowed to roll down the tracks of the first hill. The car comes to a stop before it reaches the top of the second hill.
• Two wrecking ball cranes sit next to two concrete buildings. Crane A has a ball that has less mass than the ball of Crane B. Both cranes swing their balls toward the buildings. Crane A’s ball starts out higher than Crane B’s ball. Crane A’s ball does substantially more damage to the building than Crane B’s ball.
• The poles of an electromagnet can be reversed by reversing the electromagnet’s connection to a battery.
• An empty shopping cart rolls down a hill in a parking lot and dents a parked car, while a full shopping cart rolls across a flat lot and does not damage a parked car.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
</table>

1. Select or identify from a collection of potential model components, including distractors, the components needed to model different amounts of potential energy stored in a system, compared to the distance between interacting objects. Components might include: energy source, objects in motion, and boundaries of system.
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing changes in potential energy stored in a system. This *does not* include labeling an existing diagram.
3. Manipulate the components of the model to demonstrate the changes, properties, processes, and/or events that act to result in the changes in potential energy.
4. Make predictions about the effects of changes in distances between interacting objects and the potential energy stored in the system. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5. Given models or diagrams of a system containing potential energy, identify how the energy changes over time in a given scenario OR identify the properties of the variables that cause the changes.
6. Identify missing components, relationships, or other limitations of the model.
7. Describe, select, or identify the relationships among components of a model that describe changes in potential energy of a system when the distance between interacting objects changes.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS PS3-3
Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.</td><td>PS3.A: Definitions of Energy
• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy
• Energy is spontaneously transferred out of hotter regions or objects and into colder ones

ETS1.A: Defining and Delimiting an Engineering Problem
• The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.

ETS1.B: Developing Possible Solutions
• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.</td><td>Energy and Matter
• The transfer of energy can be tracked as energy flows through a designed or natural system.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statement
• Examples of devices could include an insulated box and a Styrofoam cup.

Content Limits
• Students should be given the problem to solve.
• <u>Students do not need to know</u>: Calculate energy of the system or change in energy.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Engineering performance expectations are built around meaningful design problems rather than phenomena. For this performance expectation, design problems or design solutions replace phenomena.

Some examples of design problems for MS-PS3-3:
• A heated swimming pool needs to be covered to reduce energy costs in the winter.
• Many cooks prefer pans that heat more evenly. Which materials should pans be made of?
• Design a more energy-efficient window.</td></tr>
</table>

	• Choose the materials for a pot holder.
This Performance Expectation and associated Evidence Statements support the following Task Demands.	
Task Demands	
1. Identify or assemble from a collection the relevant aspects of the problem that given design solutions for either minimizing or maximizing thermal energy transfer, if implemented, will resolve/improve.	
2. Using the given information, select or identify the criteria against which the device or solution that either minimizes or maximizes thermal energy transfer should be judged.	
3. Using given information, select or identify constraints that the device or solution that either minimizes or maximizes thermal energy transfer must meet.	
4. Using given data, propose, illustrate, and/or assemble a potential device (prototype) or solution that either minimizes or maximizes thermal energy transfer.	
5. Using a simulator, test a proposed prototype and evaluate the outcomes, potentially including proposing and testing modifications to the prototype.	

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS3-4
Plan an investigation to determine the relationships among energy transferred, type of matter, mass, and change in the average kinetic energy of particles, as measured by the temperature of a sample.</td></tr>
<tr><td>Dimensions</td><td>Planning and Carrying Out Investigations
• Plan an investigation individually and collaboratively and, in the design, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.</td><td>PS3.A: Definitions of Energy
• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer
• The amount of energy transfer needed to change the temperature of a sample of matter by a given amount depends on the nature of the matter, the size of the sample, and the environment.</td><td>Scale, Proportion, and Quantity
• Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature; the temperature change of samples of different materials with the same mass as they cool or heat in the environment; or the same material with different masses when a specific amount of energy is added.

Content Limits
• Assessment does not include calculating the total amount of thermal energy transferred.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS3-4:
• A mug of hot coffee is set on a cork coaster. After letting the mug of coffee sit for a while, a person picks up the mug and the coaster and notices that both the mug and coaster are warm.
• When placed over the same heat source, water takes longer to reach 100C^0 than a cola soft drink.
• Pot holders work well when they’re dry. When they’re wet, they don’t.
• A metal spoon used to stir a hot beverage gets hot much more quickly than a wooden spoon.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
</table>

1. Identify from a list, including distractors, the materials/tools needed for an investigation of how thermal energy is transferred to and from the environment and to and from materials of different/ same types of matter and different/ same masses.
2. Identify the data that should be collected in an investigation of how thermal energy is transferred to and from the environment and to and from materials of different/ same types of matter and different/ same masses.
3. Evaluate the sufficiency and limitations of data collected to explain a phenomenon.
4. Make and/or record observations about time, mass of materials, type of materials, initial and final average kinetic energy (temperature) of materials, and the surrounding environment.
5. Interpret and/or communicate data from an investigation.
6. Explain or describe the causal processes that lead to observed data.
7. Select, describe, or illustrate a prediction made by applying the findings from an investigation.
8. Assemble or specify a controlled experiment or investigation to evaluate the effect of the type of matter, amount of heat, or volume of material heated.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS3-5
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.</td><td>PS3.B: Conservation of Energy and Energy Transfer
• When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time.</td><td>Energy and Matter
• Energy may take different forms (e.g., energy in fields, thermal energy, and energy of motion).</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on understanding that when the kinetic energy of an object increases or decreases, the energy (e.g., kinetic, thermal, potential, light, sound) of other objects or the surroundings within the system increases or decreases, indicating that energy was transferred to or from the object.
• Emphasis is on knowing that temperature is the measure of the average kinetic energy of particles of matter.
• Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object.

Content Limits
• Assessment does not include any calculations of energy or energy flow.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS3-5:
• The Riverside geyser in the Upper Geyser Basin at Yellowstone National Park throws out jets of hot water into the air at regular intervals.
• When the brakes are applied, sparks fly out between the wheels and the metal tracks as a train slows down.
• Bowling pins fall over and start to roll when struck by a bowling ball.
• A hot air balloon lifts off the ground as the burner is lit under the balloon.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information.</td></tr>
<tr><td colspan="4">2. Predict outcomes when the kinetic energy of an object changes, given the inferred cause and effect relationships.</td></tr>
</table>

3. Describe, identify, and/or select information needed to support an explanation of a change in kinetic energy or energy transfer.
4. Identify patterns or evidence in the data that support the claim that the kinetic energy of an object changes as energy is transferred to or from the object.
5. Using evidence, explain the relationship between the kinetic energy of an object and changes to the object or the surroundings, as energy is transferred to or from the object.
6. Manipulate the components of a model to demonstrate that the kinetic energy of an object changes as energy is transferred to or from the object.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS4-1
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.</td></tr>
<tr><td>Dimensions</td><td>Using Mathematics and Computational Thinking
• Use mathematical representations to describe and/or support scientific conclusions and design solutions.</td><td>PS4.A: Wave Properties
• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.</td><td>Patterns
• Graphs and charts can be used to identify patterns in data.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasize describing waves with both quantitative and qualitative thinking.
• Examples could include using graphs, charts, computer simulations, or physical models to demonstrate amplitude and energy correlation.
• All equations and formulas must be provided and be age-appropriate.

Content Limits
• Assessment does not include electromagnetic waves and is limited to standard repeating waves.
• Assessment does not include identifying or knowing characteristics of different types of waves (mechanical, electromagnetic, sonic, etc.).
• <u>Students do not need to know</u>: how two waves carrying the same energy can have different amplitudes when introduced into materials of different densities and elasticities.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS4-1:
• The 1896 Sanriku earthquake off the coast of Japan generated ocean waves that reached a height of 100 feet (30 m).
• Compared to a megaphone that sends sound messages up to 300 meters away, a Long Range Acoustic Device (LRAD) sends messages that can be heard up to 5,500 meters away.
• Scientists at the Swiss Federal Institute in Zurich caused a toothpick to levitate using sound waves.
• A wave travels down a rope from one student to another when the first student shakes it.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Compile and analyze data to make an inference about the relationship between amplitude and energy of a wave. This may include sorting out relevant from irrelevant data in the given information.</td></tr>
<tr><td colspan="4">2. Organize and/or arrange (e.g., using illustrations and/or labels) or summarize data to highlight trends, patterns, or correlations that reflect how energy changes with amplitude of a wave and vice versa.</td></tr>
<tr><td colspan="4">3. Identify how wave characteristics correspond to physical observations (e.g., wave amplitude corresponds to sound volume).</td></tr>
</table>

4. Use relationships identified in the data to predict the energy or amplitude change of a wave if the other parameter is changed.
5. Based on data, calculate or estimate one property of a wave (energy or amplitude) and the relationships between different properties of a wave.
6. Use graphs, charts, simulations, or physical models to demonstrate amplitude and energy correlation.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS4-2
Develop and/or use a model to describe that waves are reflected, absorbed, or transmitted through various materials.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and/or use a model to predict and/or describe phenomena.</td><td>PS4.A: Wave Properties
• A sound wave needs a medium through which it is transmitted.

PS4.B: Electromagnetic Radiation
• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass), where the light path bends.
• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
• However, because light can travel through space, it cannot be a matter wave, like sound or water waves.</td><td>Structure and Function
• Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statement
• Emphasis is on both light and mechanical waves.
• Examples of models could include drawings, simulations, and written descriptions. This includes amplitudes, frequencies, and wave lengths.

Content Limits
• Assessment is limited to qualitative applications pertaining to light and mechanical waves, not quantitative.
• Assessment does not include:
o Particle movement and compression waves
o Constructive or destructive interference</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS4-2:
• One part of a straw appears to be broken from the rest of the straw when viewed through the side of a glass of water.
• Music placed near a lake can be heard clearly while sitting on the shore. However, while swimming under the water, the sound cannot be heard as clearly.
• Objects are more visible during a moonlit night when there is snow on the ground vs. when there is no snow on the ground.
• Loud music moves the leaves of a plant.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Select from a collection of potential model components including distractors, the components needed to model the phenomenon. Components might include type of wave, properties of the wave, the materials with which the waves interact, the position of the source of the wave, etc.
2. Assemble, from a collection of potential model components, an illustration or flow chart that is capable of representing the movement, transmission, reflection, refraction, and absorption of waves. This does not include labeling an existing diagram.
3. Manipulate the components of a model to demonstrate the changes that cause the observed phenomenon.
4. Manipulate the components of a model to predict the behavior of waves in an alternate scenario.
5. Given models or diagrams of how a wave interacts with different materials, identify the wave properties and how they change in each scenario OR identify the properties of the different materials that cause the wave to behave differently.
6. Identify missing components, relationships, or other limitations of the model.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS4-3
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.</td></tr>
<tr><td>Dimensions</td><td>Obtaining, Evaluating, and Communicating Information
• Integrate qualitative scientific and technical information in written text with information contained in media and visual displays to clarify claims and findings.</td><td>PS4.C: Information Technologies and Instrumentation
• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information</td><td>Structure and Function
• Structures can be designed to serve particular functions.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on a basic understanding that waves can be used for communication purposes.
• Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.
• Examples could also include using vinyl record vs. digital song files, film cameras vs. digital cameras, or alcohol thermometers vs. digital thermometers.

Content Limits
• Assessment does not include binary counting.
• Assessment does not include the specific mechanism of any given device.
• <u>Students do not need to know</u>:
    o Specifics about binary or any other coding process.
    o How certain mechanisms work other than the fact that they are either analog or digital.
    o Students are not responsible for knowing the different parts of mechanisms: hard drives, USB cables, flash drives, and servers.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for Standard MS-PS4-3:
• A digital scale gives better precision on weight measurements than analog.
• Digital films are higher quality than analog films (from a film reel).
• Digital measurements provide precise values compared to analog measurements
• Digital data can be stored in a server and easily retrieved if the hardware breaks, while analog data are lost if the hardware is broken.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Identify evidence that is sufficient to support the claim that digital signals are a more reliable way to store and transmit information than analog signals.</td></tr>
</table>

2. Citing evidence, identify specific features of digital signals that make them more reliable than analog signals OR identify specific examples of how digitization of a certain technology has advanced science.
3. Gather, read and synthesize information from multiple sources and assess the credibility, accuracy, and possible bias of each publication; describe how they are supported or not supported by evidence.
4. Evaluate data and/or conclusions in scientific and technical texts in light of competing information.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-1
Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.</td></tr>
<tr><td>Dimensions</td><td>Planning and Carrying Out Investigations
• Conduct an investigation to produce data to serve as the basis for evidence that meets the goals of an investigation.</td><td>LS1.A: Structure and Function
• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).</td><td>Scale, Proportion, and Quantity
• Phenomena that can be observed at one scale may not be observable at another scale.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many varying cells.

Content Limits
• <u>Students do not need to know</u>:
o The structures or functions of specific organelles or different proteins
o Systems of specialized cells
o The mechanisms by which cells are alive
o Specifics of DNA and proteins or of cell growth and division
o Endosymbiotic theory
o Histological procedures.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-1:
• Plant leaves and roots have tiny box-like structures that can be seen under a microscope.
• Small creatures can be seen swimming in samples of pond water viewed through a microscope.
• Different parts of a frog’s body (muscles, skin, tongue, etc.) are observed under a microscope, and are seen to be composed of cells.
• One-celled organisms (bacteria, protists) perform the eight necessary functions of life, but nothing smaller has been seen to do this.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Identify from a list, including distractors, the materials/tools needed for an investigation to find the smallest unit of life (cell).</td></tr>
<tr><td colspan="4">2. Identify the outcome data that should be collected in an investigation of the smallest unit of living things.</td></tr>
</table>

3. Evaluate the sufficiency and limitations of data collected to explain that the smallest unit of living things is the cell.
4. Make and/or record observations about whether the sample contains cells or not.*
5. Interpret and/or communicate data from the investigation to determine if a specimen is alive or not.
6. Construct a statement to describe the overall trend suggested by the observed data.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-2
Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe phenomena.</td><td>LS1.A: Structure and Function
• Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.</td><td>Structure and Function
• Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore, complex natural structures/systems can be analyzed to determine how they function.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasize the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

Content Limits
• Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane.
• Assessment of the function of the other organelles is limited to their relationship to the whole cell.
• Assessment does not include the biochemical function of cells or cell parts.
• <u>Students do not need to know</u>: protein synthesis, cell division (mitosis), reproduction (meiosis).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-2:
• Skin cells act as a barrier between your insides and the outside.
• Under a microscope, a muscle cell looks different than a skin cell.
• Under a microscope, a root cell looks different than a leaf cell.
• An E. coli bacterium is approximately the same size as the mitochondria of a mammalian lung cell.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Assemble or complete, from a collection of potential model components, an illustration that is capable of representing a eukaryotic (plant and/or animal) or prokaryotic cell in terms of the function of the cell.</td></tr>
<tr><td colspan="4">2. Select or identify from a collection of potential model components, including distractors, the components needed to model the phenomenon. Components might mirror the cell wall, cell membrane, nucleus, chloroplast, and/or mitochondrion. This <u>does not</u> include labeling an existing diagram.</td></tr>
<tr><td colspan="4">3. Manipulate the components of a model to demonstrate the changes, properties, and/or events that act to result in the phenomenon.*</td></tr>
</table>

4. Given models or diagrams of cells, identify the functions of each part of the cell.
5. Identify missing components, relationships, or other limitations of the model.
6. Describe, select, or identify the relationships among components of a model that together function as a cell.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-3
Use argument supported by evidence for how the body is a system of interacting sub-systems composed of groups of cells.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.</td><td>LS1.A: Structure and Function
• In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.</td><td>Systems and System Models
• Systems may interact with other systems; they may have sub-systems and be part of larger complex systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.

Content Limits
• Assessment does not include the mechanism of one body system independent of others.
• Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular and nervous systems.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-3:
• After falling and scraping your knee, a scab forms over the wound.
• An elephant’s heart rate is slower than a mouse’s heart rate even though it is much bigger.
• A person swallows their food while doing a handstand, but a bird cannot swallow food while hanging upside down.
• When a person hasn’t eaten in a few hours and is hungry, their stomach makes an audible “growling” sound.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Based on the provided data, identify, describe or illustrate a claim regarding the relationship between cells, tissues, organs and bodily function(s).</td></tr>
<tr><td colspan="4">2. Identify, summarize, or organize given data or other information to support or refute a claim regarding the relationship between cells, tissues, organs and bodily function(s).*</td></tr>
<tr><td colspan="4">3. Sort inferences about the relationship between body systems into those that are supported by the data, contradicted by the data, or neither, or some similar classification.*</td></tr>
</table>

4. Select supporting evidence from competing sources based on the reliability of statistical relationships, how representative the sample is, or study design to show how the body is a system of interacting subsystems.
5. Construct an argument using scientific reasoning drawing on credible evidence to explain the relationships of interacting subsystems in a body such as tissues and organs. (Hand scored CR) *
6. Identify additional evidence that would help clarify, support, or contradict a hypothesized relationship or causal argument regarding the interactions of subsystems in the body.
7. Identify or describe alternate explanations and the data needed to distinguish among them in order to explain how body system functions.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-4
Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td><td>LS1.B: Growth and Development of Organisms
• Animals engage in characteristic behaviors that increase the odds of reproduction.
• Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.</td><td>Cause and Effect
• Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements:
• Examples of behaviors that affect the probability of animal reproduction could include: nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding.
• Examples of animal behaviors that affect the probability of plant reproduction could include: transferring pollen or seeds, and creating conditions for seed germination and growth.
• Examples of plant structures could include: bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.

Content Limits:
• Data analysis should be limited to calculations and interpretation of measures of central tendency.
• Students are only expected to understand probability as expected relative frequency.
• Students can be asked to evaluate whether sample data are representative and the limits to which findings can be generalized.
• Data sets can include not only common trends but also outliers and anomalous data points.
• <u>Students do not need to know</u>: Mechanisms or patterns of inheritance, meiosis, specific reproductive structures not detailed within this document (e.g., nuptial pads, dulap), detailed life cycles.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-4:
• Spring peepers (Pseudacris crucifer) in South Georgia, North Georgia, and Eastern Kentucky begin vocalizing (breeding) at different times of the year.</td></tr>
</table>

	• Female poison arrow frogs lay their eggs in leaf litter. When they hatch, male poison arrow frogs herd the tadpoles onto their backs and transport them to bromeliads, where they develop into adulthood. • The proportion of trees that are pollinated by insects decreases with latitude (phenomenon would be data tables that illustrate this relationship). • The Aspen tend to be one of the first plants to emerge after a forest fire.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Based on the provided data, identify, describe or illustrate a claim regarding the relationship between a characteristic animal behavior and/or specialized plant structure and the probability of successful reproduction in the species.
2. Identify, summarize, or organize given data or other information to support or refute a claim regarding the relationship between a characteristic animal behavior and/or specialized plant structure and the probability of successful reproduction in the species.
3. Sort inferences about the relationship of behaviors or structures to breeding success into those that are supported by the data, contradicted by the data, or neither, or some similar classification.
4. Select supporting evidence from competing sources based on the reliability of statistical relationships, how representative the sample is, or study design.
5. Construct an argument using scientific reasoning drawing on credible evidence to explain the relationships of animal behaviors or plant structures to reproductive success. (Hand scored CR)
6. Identify additional evidence that would help clarify, support, or contradict a hypothesized relationship or causal argument.
7. Identify or describe alternate explanations and the data needed to distinguish among them.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS LS1-5
Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td><td>LS1.B: Growth and Development of Organisms
• Genetic factors as well as local conditions affect the growth of the adult plant.</td><td>Cause and Effect
• Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of local environmental conditions could include availability of food, light, space, and water.
• Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms.
• Examples of evidence could include a drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.

Content Limits
• Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.
• Assessment does not include Punnett squares.
• <u>Students do not need to know</u>: epigenetics or variations of gene expression.</td></tr>
<tr><td colspan="4" align="center">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Phenomena for this performance expectation should include two groups of a particular organism with one environmental change.

Some example phenomena for MS-LS1-5:
• An orchard contains both full-sized and dwarf apple trees. Individuals of both types of tree grow shorter and produce fewer apples when planted on a dry hillside, and grow taller and produce more apples when planted on the shore of a pond. (i.e., the full apple trees on the hillside are the same size with similar apple production as the dwarf apple trees by the pond).
• Only about 90% of identical twins each have the same height.
• A group of poinsettias and daisies are grown in the same greenhouse. The poinsettias bloom when exposed to ten consecutive hours of light, but the daisies bloom when exposed to 14 consecutive hours of light.</td></tr>
</table>

	• Burrs are dispersed to different environments by traveling on the fur of mammals. Some seeds from a burr plant drop off into a sunny field, while others drop off into a shady patch of woods. The burr plants that grew in the sun are taller and produced more burrs than those that grew in the shade.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Articulate, describe, illustrate, or select genetic and/or environmental influences on phenotypic differences between organisms. This may entail sorting relevant from irrelevant information.
2. Explain the process by which genetic factors and/or local conditions cause the observed phenomenon, supporting the explanation with valid and reliable evidence (hand scored).
3. Identify evidence that supports the inference that genetic and environmental factors influence growth and development of organisms. Environmental factors may include food, light, space, and water.
4. Describe, identify, and/or select information from one or more sources to support an explanation for phenotypic differences in organisms related to genetic and environmental factors.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-6
Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td><td>LS1.C: Organization for Matter and Energy Flow in Organisms
• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life
• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen (secondary).</td><td>Energy and Matter
• Within a natural system, the transfer of energy drives the motion and/or cycling of matter.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on tracing movement of matter and flow of energy.
• Students are able to identify relationships between dependent and independent variables.

Content Limits
• Assessment does not include the biochemical mechanisms of photosynthesis.
• Assessment does not include the carbon cycle or nitrogen fixation.
• <u>Students do not need to know:</u> how to balance chemical equations.</td></tr>
<tr><td colspan="4" align="center">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-6:
• A plant is kept in a clear, closed container that allows sunlight to pass through. After one week, the plant is dead. A mouse kept alone in the same container also dies. However, a plant and mouse kept together in the same container after one week are alive.
• The plant Elodea releases bubbles at an increased rate when an aquatic animal is added to the same aquarium.
• A plant grows in a pot of soil for one month. Only water is added to the pot. After one month, the plant has gained mass, while the mass of the soil has barely changed.
• A plant leaf kept in the light contains large amounts of starch, while a leaf kept in the dark does not.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features of the reactants and products.
2. Express or complete a description of the flow of energy and/or matter among organisms. This may include indicating directions of causality in an incomplete model (including food webs), such as a flow chart or diagram.
3. Identify evidence that photosynthesis cycles matter and energy through an ecosystem.
4. Select, identify, or describe the predicted effect of a change of conditions on the flow of energy and matter among organisms.
5. Describe, identify, and/or select information needed to support an explanation.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-7
Develop a model to describe how food is rearranged through chemical reactions to form new molecules that support growth and/or release energy as this matter moves through an organism.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop a model to describe unobservable mechanisms.</td><td>LS1.C: Organization for Matter and Energy Flow in Organisms
• Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy.

PS3.D: Energy in Chemical Processes and Everyday Life
• Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)</td><td>Energy and Matter
• Matter is conserved because atoms are conserved in physical and chemical processes.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on the describing that describing that molecules are broken apart and put back together and that in this process energy is released.

Content Limits
• Assessment does not include details of the chemical reactions for photosynthesis or respiration.
• <u>Students do not need to know</u>: enzymes, ATP synthase, metabolism, biochemical pathways, redox reactions, molecular transport, specific enzymes involved, catalysts</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-7:
• A young plant is grown in a bowl of sugar water. As it grows, the amount of sugar in the water decreases.
• A person feels tired and weak before they eat lunch. After they eat some fruit, they feel more energetic and awake.
• An athlete completing difficult training feels that their muscles recover and repair faster when they eat more high-protein foods in a day compared to when they eat less protein in a day.
• Amoeba are provided food in a petri dish. When fed, the amoeba become more active and begin to grow and divide</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Select or identify from a collection of potential model components, including distractors, the components needed to model the phenomenon. Components might include gases, sugars, and organelles.</td></tr>
</table>

2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing the transformation of food + oxygen into energy and/or new compounds. This does not include labeling an existing diagram.
3. Manipulate the components of the model to demonstrate the changes, properties, processes, and/or events that act to result in the phenomenon.
4. Make predictions about the effects of changes in the type or amount of a certain component in the model. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5. Given models or diagrams of the state of model components, identify the properties of the system that give rise to the phenomenon.
6. Identify missing components, relationships, or other limitations of the model.
7. Describe, select, or identify the relationships among components of a model that describe or explain how food can be turned into energy for new growth and other activities.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-8
Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.</td></tr>
<tr><td>Dimensions</td><td>Obtaining, Evaluating, and Communicating Information
• Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.</td><td>LS1.D: Information Processing
• Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Content Limits
• Assessment does not include mechanisms for the transmission of information from sensory receptors to the brain.
• <u>Students do not need to know</u>: Sensory transduction, ion channels, action potentials, sensory and motor cortices in the brain.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-8:
• A woman closes her eyes and touches the tip of her nose with her index finger.
• A student is studying in a library. The fire alarm goes off and he involuntarily jumps out of his chair.
• A woman walking past a bakery smells cinnamon and is instantly reminded of her grandmother’s house.
• A driver sees a stoplight change from green to red and quickly moves his foot from the accelerator pedal to the break.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Analyze and interpret scientific evidence from multiple scientific/technical sources including text, diagrams, charts, symbols and mathematical representations to describe how external stimuli are sensed by the brain.</td></tr>
<tr><td colspan="4">2. Assemble or complete an illustration or flow chart representing physiological or behavioral responses to external stimuli.</td></tr>
<tr><td colspan="4">3. Based on the information provided, identify or describe supporting evidence for an argument regarding the relationship between an external stimulus, sensory receptors and/or a particular behavior.</td></tr>
<tr><td colspan="4">4. Make predictions about the effects on sensory receptors, immediate behavior, or memory storage as a result of changes to an external stimulus. Predictions can be quantitative or qualitative and can be made by completing illustrations, or selecting from lists with distractors.</td></tr>
</table>

5. Evaluate the validity, credibility, accuracy, relevancy and/or possible bias of scientific/technical sources.
6. Synthesize an explanation regarding sensory stimuli that incorporates scientific evidence from multiple sources.
7. Identify, summarize, or organize given data or other information to support or refute a claim relating the characteristics of an external stimulus to a sensory pathway.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-1
Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to provide evidence of phenomena.</td><td>LS2.A: Interdependent Relationships in Ecosystems
• Organisms, and populations of organisms, are dependent on their environmental interactions, both with other living things and with nonliving factors.
• In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
• Growth of organisms and population increases are limited by access to resources.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on cause and effect relationships between resources and growth of individual organisms, and the numbers of organisms in ecosystems during periods of abundant and scarce resources.
• Examples could include water, food, and living space

Content Limits
• Assessment does not include mathematical and/or computational representations of factors related to carrying capacity of ecosystems of different sizes (including deriving mathematical equations to make comparisons).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">The phenomena for this performance expectation are the given data. Samples of phenomena should describe the data set(s) to be given in terms of patterns or relationships to be found in the data, and the columns and rows of a hypothetical table presenting the data, even if the presentation is not tabular. The description of the phenomenon should describe the presentation format of the data (e.g., maps, tables, graphs, etc.).

Some example phenomena for MS-LS2-1:
• On the north Atlantic coastline, two species of barnacles live at different depths
• Cheetahs and leopards in the savannah use the same watering holes.
• After a drought period, the population of grasshoppers is halved.
• A garden is cleared of aphids. After a few days, the ladybirds in the surrounding trees are gone.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
</table>

1. Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations between resource availability and the growth of a population or populations of organisms.
2. Generate or construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations between resource availability and the growth of a population or populations of organisms. This may include sorting out distractors.*
3. Use relationships identified in resource/population data to predict the change in a population or populations or the change in resources that resulted in a change in populations.**
4. Identify patterns or evidence in the data that supports inferences and explanations about how resource availability affects a population of organisms.*
5. Construct or identify testable questions that can be asked to collect data about how resource availability may affect the growth of a population or populations of organisms.
6. Identify, describe, or select from a collection characteristics to be manipulated or held constant while gathering information to answer a well-articulated question.*
7. Select or describe inferences relevant to the question posed and supported by the data, especially inferences about causes and effects.
8. Select, identify, or describe predicted outcomes when specific changes in resource availability occur, using inferences about cause and effect relationships involving those resources.**

*denotes those task demands which are deemed appropriate for use in stand-alone item development
**TD3 and TD8 must be used together.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-2
Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.</td><td>LS2.A: Interdependent Relationships in Ecosystems
• Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.</td><td>Patterns
• Patterns can be used to identify cause and effect relationships.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statement
• Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between living organisms and nonliving components of ecosystems.
• Examples of types of interactions could include competitive, predatory, and mutually beneficial.

Content Limits
• Analysis may include recognizing patterns in data, specifying and explaining relationships, making logical predictions from data, retrieving information from a table, graph or figure and using it to explain relationships, generating hypotheses based on observations or data, and generalizing a pattern.
• Analysis should not include relating mathematical or scientific concepts to other content areas.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">For this performance expectation, the phenomena are sets of data. Those are the observed facts that the students will look at to discover patterns. Below, we enumerate some of the patterns that might comprise the data sets (phenomena) to be analyzed. Patterns should be observed across at least two different environments/habitats.

Patterns that describe the data sets for MS-LS2-2:
• The tongue of the alligator snapping turtle looks like a small worm. The turtle uses this tongue to lure prey close to its mouth. (Predation)—also angler fish.
• Higher density of squirrels in oak environment than in maple environment.</td></tr>
</table>

<table>
<tr><td></td><td>Hippopotamuses spend time in both aquatic and savannah ecosystems. When found in aquatic environments, they’re often surrounded by carp. When found in a savannah environment, they’re often surrounded by oxpeckers.
In Ecuador’s Andean Cloud Forest, a hummingbird feeds on the nectar of an orchid flower (Epidendrum secundum). In the Madagascar, a similar orchid flower (Angraecum sesquipedale) is seen, but no hummingbirds are found.</td></tr>
<tr><td colspan="2">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="2">Task Demands</td></tr>
<tr><td colspan="2">1. Articulate, describe, illustrate, or select the relationships or interactions to be explained. This may entail sorting relevant from irrelevant information or features.</td></tr>
<tr><td colspan="2">2. Express or complete a causal chain common or distinct across organisms or environments. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram or completing cause and effect chains.*</td></tr>
<tr><td colspan="2">3. Identify evidence supporting the inference of causation of patterns of interactions among organisms across multiple ecosystems expressed in a causal chain.*</td></tr>
<tr><td colspan="2">4. Use an explanation to predict interactions among different organisms or in different environments.</td></tr>
<tr><td colspan="2">5. Describe/Identify/Select information needed to support an explanation of patterns of interactions among organisms across multiple ecosystems.</td></tr>
</table>

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-3
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop a model to describe phenomena.</td><td>LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
• Food webs are models that demonstrate how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.</td><td>Energy and Matter
• The transfer of energy can be tracked as energy flows through a natural system.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.
Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.
Content Limits
Students do not need to identify biomes or to know information about specific biomes.
Assessment does not include
The use of chemical reactions to describe the processes.
Identification of trophic levels, understanding of the relative energies of the trophic levels, nor the knowledge of the 10% energy transfer between trophic levels.
The process of bioaccumulation.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS2-3:
In the Alaskan tundra, more grass and wildflowers grow on top of underground fox dens than elsewhere.
In July, a colony of lava crickets is found to inhabit lava flows from a May eruption, but the first plant does not appear in the area until November.
Fox-inhabited islands in the Aleutian Islands have less vegetation than islands not inhabited by foxes.
Giant clams and tube worms are found in the darkest parts of the oceans in the hot water near hydrothermal vents.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
</table>

1. Identify, assemble, or complete from a collection of potential model components, including distractors, components of a food-web model that describe transfers of matter and/or energy among producers, consumers, decomposers, or some subsets of those, potentially including transfers between living and nonliving organisms.
2. Describe, select, or identify the relationships among components of a food-web model that describes how parts of the food web (producers, consumers, and decomposers) interact to continually cycle matter and to transfer energy among living and nonliving parts of an ecosystem.
3. Manipulate the components of a food-web model to demonstrate how the interactions among producers, consumers, and/or decomposers result in changes to the cycling of matter and/or transfer of energy among living and nonliving parts of an ecosystem.
4. Select, describe, or illustrate predictions about the effects of changes in the organisms or nonliving components of the environment on the cycling of matter, transfer of energy, and/or other organisms in the environment. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5. Select or identify missing components or relationships of a food web model that describes the transfers of matter and/or energy among living and nonliving parts of an ecosystem.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-4
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td><td>LS2.C: Ecosystem Dynamics, Functioning, and Resilience
• Ecosystems are dynamic in nature: their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.</td><td>Stability and Change
• Small changes in one part of a system might cause large changes in another part.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.

Content Limits
• Assessment does not include the use of chemical reactions to describe the processes.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Example Phenomena for MS-LS2-4:
• After a beaver builds a dam, the amount and diversity of fish life in a stream increases.
• After wolves were reintroduced to Yellowstone, there were more willows.
• The number of willows has increased in Yellowstone. (Give two competing hypotheses: wolf introduction; beaver population increase).
• As the Aral Sea declined in size since the 1960s, salinity has increased and the Aral trout is no longer present in the lake.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or information supporting/refuting one or more competing hypotheses.</td></tr>
<tr><td colspan="4">2. Predict outcomes when changes to an ecosystem occur, given the inferred cause and effect relationships.*</td></tr>
<tr><td colspan="4">3. Identify, select, and/or describe information or evidence needed to support one or more potentially competing explanations.</td></tr>
<tr><td colspan="4">4. Identify patterns of information/evidence in the data that support correlative/causative inferences about the relationships among the pertinent parts of an ecosystem.*</td></tr>
</table>

5. Organize and/or arrange (e.g., using illustrations and/or labels) or summarize population data to highlight trends, patterns, or correlations.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-5
Evaluate competing design solutions for maintaining biodiversity and ecosystem services.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.</td><td>LS2.C: Ecosystem Dynamics, Functioning, and Resilience
• Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans
• Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, fresh air and water (secondary).

ETS1.B: Developing Possible Solutions
• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem (secondary).</td><td>Stability and Change
• Small changes in one part of a system may cause a large change in another part.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion.
• Examples of design solution constraints could include scientific, economic, and social considerations.

Content Limits
• <u>Students do not need to know:</u> specific policies or specific details of organisms.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Engineering performance expectations are built around meaningful design problems rather than phenomena. In this case, the design problems involve preserving ecosystems and protecting biodiversity. For this performance expectation, the design problem and competing solutions replace phenomena.

Some example design problems for MS-LS2-5:
• Giant African Land Snails were brought to Florida by a boy who smuggled three snails into Florida. His grandmother released these into a garden and the snail population exploded. The snails eat over 500 plant species, tree bark, paint, and even stucco. Florida has implemented four solutions:
o Trained dogs that sniff out snails for capture.
o Chemicals applied to plants that the snails feed upon.
o Predatory species to eat the snails.</td></tr>
</table>

<table>
<tr><td></td><td>The brown tree snake was accidentally brought to the island of Guam by ships during World War II, fed on native birds until the Guam rail, a native bird, nearly went extinct in 1984. Guam has implemented two solutions:
Feed rats acetaminophen and drop them into wooded areas.
Bring in predatory species to eat the snakes.
Cheatgrass, a type of weed that was brought to the United States in the late 1800s, has spread all over Utah from the desert valleys to the mountains, growing faster than most native plants. Utah has implemented two solutions:
Use genetically modified seeds for certain native seeds that are heartier than the Cheatgrass to push out the Cheatgrass seeds.
Controlled application of herbicides.
Asian carp is an aggressive fish species introduced in 1960 to control weed populations in waterways in southern fish farm ponds. The population was sterilized but a few fertile fish escaped into the Mississippi River and migrated north towards the Great Lakes. Asian carp are an invasive species that compete with native fish in the Great Lakes and threaten the ecosystem balance. Regions around the Great Lakes are implementing strategies:
Launch a campaign to encourage and incentivize fishing of Asian carp for human consumption
Use a system of electric barriers to prevent Asian carp from entering Lake Michigan from the Mississippi River.
Use nets to block paths to popular spawning sites during Asian carp reproduction season.
Introduce a botanic pesticide used for fish eradications in water areas known to have large Asian carp populations.</td></tr>
<tr><td colspan="2">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="2">Task Demands</td></tr>
<tr><td colspan="2">1. Identify or assemble from a collection, including distractors, the relevant aspects of the problem that, given design solutions if implemented, will resolve/improve maintaining biodiversity and ecosystem services.</td></tr>
<tr><td colspan="2">2. Using given information for maintaining biodiversity and ecosystem services, select or identify constraints that the device or solution must meet.</td></tr>
<tr><td colspan="2">3. Using the given information for maintaining biodiversity and ecosystem services, select or identify the criteria against which the device or solution should be judged.</td></tr>
<tr><td colspan="2">4. Compare, rank, or otherwise evaluate the different design solutions for maintaining biodiversity and ecosystem services against the identified criteria.</td></tr>
<tr><td colspan="2">5. Select or propose a recommended course of action supported by the design solution’s ability to meet identified criteria.</td></tr>
</table>

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS3-1
Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of an organism.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using a Model
• Develop and use a model to describe phenomena.</td><td>LS3.A: Inheritance of Traits
• Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.

LS3.B: Variation of Traits
• In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Through rare, mutations my result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.</td><td>Structure and Function
• Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among their parts; therefore, complex natural structures/systems can be analyzed to determine how they function.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on the conceptual understanding that changes in genetic material may result in making different proteins.

Content Limits
• Assessment does not include specific changes of genes at the molecular level, mechanisms for protein synthesis, and specific types of mutations.
• Do not use examples of mutations in humans.
• Analysis does not include species-level sources of genetic variation, including the founder effect, bottleneck, genetic drift or Hardy-Weinberg equilibrium.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS3-1:
• Use of antibiotics in farming has leeched antibiotics into the water system. However, resistant bacteria persist in groundwater and are difficult to kill.
• Wild almond trees produce the poisonous chemical amygdalin. Occasional individual almond trees have a mutation that cause them not to produce amygdalin. These individual plants are cultivated on almond farms.
• A farmer observed one corn plant producing corn cobs with larger kernels. The farmer planted seeds from that plant and the offspring corn plants also had larger kernels.</td></tr>
</table>

	• Thale cress plants sprout in the spring and flower about a month later.
This Performance Expectation and associated Evidence Statements support the following Task Demands.	
Task Demands	
1. Select or identify from a collection of potential model components, including distractors, the components needed to model a phenomenon. Components might match a phenotypic change resulting from a mutation to various environments, to determine whether a mutation is beneficial, harmful, or neutral to the individual.	
2. Assemble or complete, from a collection of potential model components, an illustration that is capable of representing the effects of a mutation in an individual in a specific environment. This <u>does not</u> include labeling an existing diagram.	
3. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to result in a phenomenon.	
4. Make predictions about the effects of changes in an organism's ability to survive and reproduce based on the mutation and/or environment. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.	
5. Given models or diagrams of phenotypic changes due to mutation, identify and describe why the mutation may positively, negatively, or neutrally affect the individual in different environments.	
6. Identify or select the relationships among components of a model that describe the rationale behind the beneficial, harmful, or neutral nature of a mutation in specific environments.	

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS3-2
Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe phenomena.</td><td>LS1.B: Growth and Development of Organisms
• Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring (secondary).

LS3.A: Inheritance of Traits
• Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.

LS3.B: Variation of Traits
• In sexually reproducing organisms, each parent contributes (at random) half of the genes acquired by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on using models such as Punnett Squares, diagrams and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

Content Limits
• Assessment does not include phases of mitosis or meiosis.
• <u>Students do not need to know</u>: process of recombination</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS3-2:
• Jellyfish will produce both clones and genetically diverse offspring during different stages of their life cycle.
• Strawberry plants grow another stem from a core stem that extends horizontally on the ground. This new stem will become a separate strawberry plant.
• A flatworm is cut in half. Rather than dying, both halves regenerate their lost portions to form two new, distinct, and fully functioning worms.
• A plant (Bryophyllum diagremontianum) native to Madagascar has what appears to be miniature clusters of leaves lining the edges of a much larger leaf.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Select or identify from a collection of potential model components, including distractors, the components needed to model the phenomenon. Components might include alleles, genotypes, and phenotypes.
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing different types of reproduction. This *does not* include labeling an existing diagram.
3. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to result in a phenomenon.
4. Make predictions about the effects of genetic variation from reproduction. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5. Given models or diagrams of types of reproduction, identify the types of reproduction and how they change in each scenario OR identify the properties of the different types of reproduction that cause genetic variation.
6. Identify missing components, relationships, or other limitations of the model.
7. Identify, calculate, or select the relationships among the components of a model that describe the types of reproduction, the environmental conditions under which reproduction occurs, or explain the genetic variation that results from reproduction.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS4-1
Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth, under the assumption that natural laws operate today as in the past.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to determine similarities and differences in findings.</td><td>LS4.A: Evidence of Common Ancestry and Diversity
• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.</td><td>Patterns
• Graphs, charts, and images can be used to identify patterns in data.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statement
• Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.

Content Limits
• Does not include: genetic analysis, comparisons of fossils to extant organisms, embryological evidence, genetic variation, inheritance, selective pressures.
• <u>Students do not need to know</u>: the names of individual species/genera or intervals of geological time, taxonomy, processes of fossil formation.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">For this performance expectation the phenomena are sets of data. These are the observed facts that the kids will look at to discover patterns. Below, we enumerate some of the patterns that might comprise the data sets (phenomena) to be analyzed.

Stimuli might commonly include one or more geological column, data on what fossils are found in that (those) column(s), and the characteristics of those fossils. When more than one column is to be used in the analysis, sufficient data are given to anchor the ages of one or more key strata. Students would set out to identify and articulate patterns in the data.

Patterns that describe the data sets for MS-LS4-1:
• The first feather-like structures, associated with dinosaurs, appear in the fossil record close to 200 million years ago. Over the next 50 million years, a great variety of dinosaurs and true birds appeared, showing a great variety of feathers.
• In North America, in the late C, a diverse assemblage of fossils is found. In the early Tertiary, there are far fewer types of fossils.</td></tr>
</table>

<table>
<tr><td></td><td>Prior to 542 million years ago, the fossil record shows relatively simple organisms without much variation. Layers in the fossil record between 542 million years ago to 476 million years ago shows the Cambrian Explosion—a time of significant evolution of animals, beginning with trilobites and ending with vertebrate fish. The Cambrian Explosion closed with a major extinction.
525-year-old rock layers contain the earliest vertebrate fossils, which are of fish. These fossil fish had a cartilage skull with no jaw, and lacked a vertebral column. Fossils in 450-million-year-old rocks include vertebrate fish with a cartilage jaw and vertebral column. 400-year-old rocks include fish with skulls that include jaws and vertebrates made of bone.</td></tr>
<tr><td colspan="2">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="2">Task Demands</td></tr>
<tr><td colspan="2">1. Organize and/or arrange (e.g., using illustrations and/or labels) data that document patterns of change in the fossil record related to changes in anatomical structures or organism appearance/disappearance.</td></tr>
<tr><td colspan="2">2. Generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns of change in the fossil record related to changes in anatomical structures or organism appearance/disappearance. This may include sorting out distractors.</td></tr>
<tr><td colspan="2">3. Determine or describe evidence that supports data on the timing of a mass extinction event, emergence/extinction of a new species/trait, and/or patterns of changes in biodiversity and organism complexity over time.</td></tr>
<tr><td colspan="2">4. Identify/describe/illustrate/assemble sequences over time describing changes in characteristics of organisms, the diversity of the characteristics, the diversity of organisms, or the relative frequencies of the characteristics. This may include selecting a pattern from a list.</td></tr>
</table>

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS4-2
Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.</td><td>LS4.A: Evidence of Common Ancestry and Diversity
• Anatomical similarities and differences among organisms living today, and between contemporary organisms and those in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.</td><td>Patterns
• Patterns can be used to identify cause and effect relationships.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on explanation of the relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.
• Emphasis is on using anatomical similarities and differences to infer relationships among different modern organisms.
• Emphasis is on understanding that the changes over time in the anatomical features seen in fossil records can be used to infer relationships between extinct organisms to living organisms.
• Emphasis is on understanding that organisms that share a pattern of anatomical features are likely to be more closely related than are organisms that do not share a pattern of anatomical features.

Content Limits
• <u>Students do not need to know:</u> name of specific fossil species; knowledge of specific fossils or anatomical features; genetic variation, process of fossil formation, knowledge of geologic time periods; knowledge of rock layer; relationship between fossils and age of rock layers; molecular homology (similarities in DNA, RNA, and protein sequence).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS4-2:
• Bats and frogs have forelimbs that look very different, but have similar bones and overall structure.
• Comparing the skull bones of the modern-day whale to the fossilized skulls of Dorudon and Pakicetus, shows a pattern in the position of the nostril as these organisms changed over millions of years.
• Wings are structures that allow most birds to fly, except penguins, which have wings but cannot fly.
• Modern-day whales live in the ocean but have small hind-legs.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.
2. Express or complete a causal chain explaining how homologous structures show common ancestry and analogous structures show common function. This may include indicating directions of causality in an incomplete model, such as a flow chart or diagram, or completing cause and effect chains.*
3. Identify evidence supporting the inference of causation that is expressed in a causal chain.
4. Describe, identify, and/or select information needed to support an explanation.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS4-3
Analyze displays of pictorial data to compare patterns of similarities in embryological development across multiple species to identify relationships not evident in the fully formed anatomy.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze displays of data to identify linear and nonlinear relationships.</td><td>LS4.A: Evidence of Common Ancestry and Diversity
• Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy.</td><td>Patterns
• Graphs, charts, and images can be used to identify patterns in data.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic of diagrams or pictures.

Content Limits
• Assessment of comparisons is limited to observable (with the naked eye) appearances of anatomical structures in embryological development.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">For this performance expectation, the data will consist of pictures, diagrams, etc. Students will be challenged to find patterns and similarities.

Some example phenomena for MS-LS4-3:
• Early mammal embryos and early fish embryos both contain gill slits. In fish embryos, these gill slits develop into gills. In human embryos, the gill slits disappear before birth.
• The embryos of chickens, humans, and koalas have tails, and muscles to move the tails. However, as the embryos develop, the tails disappear.
• The limb buds of early bird embryos are very similar to the limb buds of early human embryos. The limb buds of the bird embryos become wings, while the limb buds of human embryos become arms.
• The early embryos of fish, birds, rabbits, and humans all have two-chambered hearts.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Summarize data to highlight trends, patterns, or correlations in the similarities or differences of the embryonic development of different species.</td></tr>
<tr><td colspan="4">2. Use relationships identified in the patterns of embryology data to predict the relatedness of different species.</td></tr>
</table>

3. Construct a statement that can potentially explain the observed trends or relationships in embryology data.
4. Identify patterns or evidence in the data that support inferences about the development of different species.
5. Identify additional information needed to support or challenge inferences based on identified patterns.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS4-4
Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals’ probability of surviving and reproducing in a specific environment.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.</td><td>LS4.B: Natural Selection
• Natural selection leads to the predominance of certain traits in a population, and the suppression of others.</td><td>Cause and Effect
• Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on using simple probability statements and proportional reasoning to construct explanations.
• Emphasize the use of proportional reasoning to support explanations of trends in changes to populations over time.
• Examples could include camouflage, variation of body shape, speed and agility, or drought tolerance.

Content Limits
• <u>Students do not need to know</u>: dominant/recessive traits, modes of inheritance (polygenic, sex-linked, etc.).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS4-4:
• The orchid mantis attracts pollinators of the orchid as prey.
• In New Mexico, the rock pocket mice found in dark, rocky areas of the Valley of Fire all have dark fur.
• Male frigate birds with larger red pouches are more likely to find a mate.
• Some Staphylococus aureus bacteria are able to survive following treatment with the antibiotic methicillin.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Describe or select the relationships, interactions, or processes to be explained. This may entail sorting relevant from irrelevant information or features.</td></tr>
<tr><td colspan="4">2. Complete a causal chain explaining how genetic variation affects the probability of survival and reproduction. This may include indicating directions of causality in a flow chart, diagram, or cause and effect chain.</td></tr>
<tr><td colspan="4">3. Identify evidence supporting the role of genetic variation in determining the probability of survival and reproduction of an organism.</td></tr>
</table>

4. Predict changes in the frequency of a trait, given a change in the environment.
5. Identify the information needed to support an explanation for how genetic variation affects the rate of survival and reproduction.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS4-5
Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.</td></tr>
<tr><td>Dimensions</td><td>Obtaining, Evaluating, and Communicating
• Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and method used, and describe how they are supported or not supported by evidence.</td><td>LS4.B: Natural Selection
• In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.</td><td>Cause and Effect
• Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy) and on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.

Content Limits
• <u>Students do not need to know</u>: overlapping DNA sequences, Hardy-Weinberg calculations, biodiversity, mechanisms of gene transfer, dominant/recessive genes.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS4-5:
• There is no wild plant that looks like modern corn (soft starchy kernels lined up in a row).
• Farmers isolated wild cabbage plants to create a variety of vegetables, including broccoli and kale. The wild cabbage plants were selected for their different flavors, textures, leaves, and flowers.
• Scientists are currently working to breed sheep that do not burp in order to reduce methane emission.
• Scientists want to breed strong and more resistant bees that won't be damaged by disease and other parasites.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Generate or construct tables or assemblages of data that document the similarities and differences between traditional and modern gene selection.</td></tr>
<tr><td colspan="4">2. Organize and/or arrange data of the success rates of different methods to highlight trends or patterns in genetic modification.</td></tr>
</table>

3. Use relationships identified in the data to predict the best gene selection method to use in a given situation.
4. Identify, among distractors, the potential real-world uses of this data.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS4-6
Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.</td></tr>
<tr><td>Dimensions</td><td>Using Mathematics and Computational Thinking
• Use mathematical representations to support scientific conclusions and design solutions.</td><td>LS4.C: Adaptation
• Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.</td><td>Cause and Effect
• Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statement
• Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.

Content Limits
• Math can include measures of central tendency, basic operations that can be calculated without a calculator, and basic graphical analysis (bar chart, pie chart, scatter plot, box and whisker plot, line chart).
• Students aren’t expected to know the mechanisms of genetic inheritance or mutation.
• Assessment does not include Hardy-Weinberg calculations.
• Assessment does not include other mechanisms of evolution (genetic drift, co-evolution, gene flow, etc.)
• <u>Students do not need to know</u>: Alleles, DNA sequences, anatomical structures, embryonic development, gene frequency, morphology, speciation.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS4-6:
• Some bacteria are killed by a certain antibiotic while other bacteria are immune to it. After the antibiotic is used once, bacteria die. The next time the antibiotic is used, there are many bacteria left.
• The Sandhills in Nebraska used to be covered in dark-colored soil. Most deer mice living in this area had dark-colored fur coats, while others had light-colored fur coats. Over time, the Sandhills were covered in light-colored sand. After many years, the population of deer mice had mostly light-colored fur coats. This will be presented as data.
• In the Galapagos Islands, there are finches with thin, small beaks that eat small, soft seeds. There also finches with thick, large beaks that eat larger hard and dry seeds. A drought</td></tr>
</table>

	period in 1977 affected the plant life on the islands, greatly reducing the number of small, soft seeds. The next year, there were far more large-beaked birds than small-beaked birds.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Make simple calculations using given data to calculate or estimate changes in the prevalence of specific traits over time.
2. Illustrate, graph, or calculate the prevalence of specific traits passed on in observed populations under varying conditions, from given data. The data may be ordinal and the calculations may be representations of trends or propensities.
3. Calculate or estimate properties or relationships of the changes in the distribution of traits among a population under varying conditions, based on data from one or more sources.
4. Compile, from given information, the data needed for a particular inference about the relationship between changes in the environment and changes in the traits of a population.
5. Use mathematical representations and/or computational representations (such as trends, averages, histograms, graphs, spreadsheets) to identify relationships in the data.
6. Use mathematical representations and/or computational representations (such as trends, averages, histograms, graphs, spreadsheets) to explain the influence that natural selection has had on the presence of specific traits in a population over time.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS1-1
Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and the seasons.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe phenomena.</td><td>ESS1.A The Universe and Its Stars
• Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.

ESS1.B Earth and the Solar System
• This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.</td><td>Patterns
• Patterns can be used to identify cause and effect relationships.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of models can be physical, graphical, or conceptual.

Content Limits
• Students do not need to know Earth’s exact tilt; sidereal and synodic periods; umbra and penumbra (the term “shadow” should be used); times of moonrise and moonset; precession; exact dates of equinoxes and solstices (but knowledge of the months in which they occur is reasonable to assess).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS1-1:
• When observed from Earth over the course of a month, the appearance of the moon changes.
• A full moon occurs in every calendar month. However, an eclipse of the moon does not occur in every calendar month.
• A new moon occurs in every calendar month. However, a total eclipse of the sun is a rare event.
• In the northern hemisphere, July is a summer month. In the southern hemisphere, July is a winter month.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Select or identify from a collection of potential model components, including distractors, components needed for a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, or seasons on Earth.</td></tr>
</table>

Components might include the sun, moon, Earth, solar energy, the moon’s orbital trace, Earth’s orbital trace, the angle of the moon’s orbital trace, the angle of Earth’s orbital trace, Earth’s axis, or the tilt of Earth’s axis.
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing the causes of lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. This <u>does not</u> include labeling a simple diagram of the Earth-sun-moon system.
3. Describe, select, or identify the relationships among components of a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. Components might include the sun, moon, Earth, solar energy, the moon’s orbital trace, Earth’s orbital trace, the angle of the moon’s orbital trace, the angle of Earth’s orbital trace, Earth’s axis, or the tilt of Earth’s axis.
4. Manipulate the components of a model to demonstrate how the relationships among the sun, the moon, Earth, and solar energy change to result in lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. *****
5. Make predictions about the effects of changes in the relationships among the sun, the moon, Earth, and solar energy as they relate to lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors. *****
6. Identify missing components, relationships, or other limitations of a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS1-2
Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe phenomena.</td><td>ESS1.A: The Universe and Its Stars
• Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

ESS1.B: Earth and the Solar System
• The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
• The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.</td><td>Systems and System Models
• Models can be used to represent systems and the interactions in a system.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy, and controls orbital motions within them.
• Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).
• Focus should be on qualitative comparisons, not quantitative.

Content Limits
• Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.
• Assessment does not include specific facts about any planets or moons.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS1-2:
• Satellites orbit Earth but can fall out of orbit (Skylab, UART satellite).
• Halley's Comet can be seen as it travels past Earth every 75–76 years.
• Rings are present around some planets.
• Mars has two moons, Phobos and Deimos, which orbit the planet.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Select or identify from a collection of potential model components, including distractors, the components needed for a model that describes the role of gravity in celestial bodies.</td></tr>
</table>

2. Assemble or complete, from a collection of potential model components, an illustration, diagram or description that is capable of representing forces and their influences on the motion of celestial bodies and/or man-made objects in orbit. This does not include labeling an existing diagram.
3. Describe, select or identify the relationships among components of a model that can explain the role of gravity in the motions of galaxies and the solar system. Components might include the sun, the moon, Earth, Milky Way galaxy, other planets and their moons.
4. Manipulate the components of a model to demonstrate how the relationships among the sun, the Earth, the moon, planets in the solar system, and galaxies change the resulting gravitational force between/or motions of those bodies.*
5. Make predictions about the effects of changes in mass/distance/how fast an object travels in a given model on other objects in the system. Predictions can be based on manipulating model components, completing illustrations, or selecting from a list including distractors.
6. Identify missing components, relationships, or other limitations of a model that can explain the role of gravity.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS ESS1-3
Analyze and interpret data to determine scale properties of objects in the solar system.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to determine similarities and differences in findings.</td><td>ESS1.B: Earth and the Solar System
• The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.</td><td>Scale, Proportion, and Quantity
• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes and spacecraft to determine similarities and differences among solar system objects.
• Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius.
• Examples of data include statistical information, drawings and photographs, and models.

Content Limits
• Assessment does not include recalling facts about properties of the planets and other solar system bodies.
• <u>Students do not need to know</u>: Facts about properties of the planets and other solar system bodies, scientific notation.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">The phenomena for this performance expectation are the given data. Samples of phenomena should describe the data set(s) to be given in terms of patterns or relationships to be found in the data, and the columns and rows of a hypothetical table presenting the data, even if the presentation is not tabular. The description of the phenomenon should describe the presentation format of the data (e.g., maps, tables, graphs, etc).

Some example phenomena for MS-ESS1-3:
• Four of Jupiter’s moons can be clearly seen through a small telescope under low magnification. These moons appear as tiny dots arranged around Jupiter.
• Close-up pictures from the New Horizons mission provided new evidence about the dwarf planet, Pluto, which was not able to be gathered by distant observations and calculations (surface features, scale).
• The sun and the moon appear as approximately the same size in the sky, but the sun is vastly larger than the moon (scale).
• Even though the moon is infinitesimally smaller than the sun, the entire sun is blocked from view on Earth during a solar eclipse (scale).</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
</table>

Task Demands
1. Make simple calculations using given data to estimate the properties (e.g., mass, surface temp., diameter) and locations of different solar system objects relative to a given reference point/object.
2. Illustrate, graph, or identify relevant features or data that can be used to estimate properties of objects or relationships in our solar system.
3. Calculate, estimate or identify properties of objects or relationships among objects in the solar system, based on data from one or more sources.*
4. Compile, from given information, the data needed for a particular inference about scale or other properties of an object.
5. Given a partial model of objects in the solar system, identify objects or relationships that can be represented in the model or the reasons why they cannot be represented in the model.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS1-4
Construct a scientific explanation based on evidence from rock strata for how the geologic timescale is used to organize Earth’s 4.6-billion-year-old history.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td><td>ESS1.C: The History of Planet Earth
• The geological time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.</td><td>Scale, Proportion and Quantity
• Time, space, and energy phenomena can be observed at various scales, using models to study systems that are too large or too small.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth’s history.
• Example of Earth’s major events could range from being geologically recent (e.g., the most recent glacial period or the earliest fossils of Homo sapiens) to geologically very old (e.g., the formation of Earth or the earliest evidence of life).
• Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant instances of volcanic eruptions.

Content Limits
• Assessment does not include recalling the names of specific periods and epochs or events within them.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS1-4:
• A very distinct clay layer tops the Hell Creek Formation in Montana. Below this layer, the Hell Creek is rich in dinosaur fossils; above the layer, no dinosaurs are found.
• The landscape of Cape Cod, Massachusetts, is almost entirely small hills of sand and gravel. However, a hole drilled 500 feet into the ground will hit hard metamorphic rock.
• In Box Canyon in Ouray, Colorado, metamorphic rocks that are standing vertical are capped by sedimentary rocks that are lying flat.
• The St. Peter Sandstone is a very white sandstone rock layer exposed in many places in the midwestern United States. The St. Peter is very uniform in appearance but the rock layer sits on top of different kinds of rocks in the North than it does in Missouri.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
</table>

1. Organize and/or arrange (e.g., using illustrations and/or labels, including taken from or added to, stratigraphic columns and/or geologic maps), or summarize, data/information so as to highlight trends, patterns, or correlations in paleoenvironmental changes, geological events/processes, and/or the appearance or disappearance in the record of specific organisms.*****
2. Generate/construct graphs, tables, or assemblages of illustrations, and/or labels of data/information that document patterns, trends, or correlations in how rock types and included fossils change over geologic time, recording different events and paleo environments. This may include sorting out distractors.*****
3. Use relationships identified in the data/information to hypothesize the relative age of specific rock layers, formations, or fossils, in a stratigraphic column or on a geologic map.*****
4. Identify patterns or evidence in the data/information that support inferences about what the paleoenvironment was like during time intervals represented in a stratigraphic column or on a geologic map.
5. Describe, identify, and/or select information needed to support an explanation.

*denotes those task demands which are deemed appropriate for use in stand-alone item development. 2/3 of these TDs should be combined and used when developing a stand-alone item.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS2-1
Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe the phenomena.</td><td>ESS2.A: Earth’s Materials and Systems
• All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.</td><td>Stability and Change
• Explanations of stability and change in natural or designed systems can be contructed by examining the changes over time and processes at different scales, including the atomic scale.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on the processes of melting, crystallization, weathering, sedimentation, and deformation, which act together to form minerals and rocks through the cycling of Earth’s matter.

Content Limits
• Assessment does not include the identification and naming of minerals.
• <u>Students do not need to know</u>: specific processes of chemical or biogeochemical weathering; rock phase diagrams; mineral stability diagrams; mineral weathering orders; mineral crystallization orders (e.g., Bowen’s Reaction Series); mineral metamorphism orders/temperatures/pressures/stabilities; rock metamorphism zones; specific processes that drive the tectonic engine (e.g., slab pull; ridge push).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS2-1:
• Lava from an erupting volcano in Hawaii flows across a road. The molten material is so hot that it emits light. Several months later, the material covering the road is a hard, black rock.
• A mountain is capped by metamorphic rock. Many cracks crisscross the rock. Rainwater often fills the fractures, freezing when temperatures drop. Over the years, the fractures become wider.
• An exposure of bedded sandstone has been cut by a plug of igneous rock. Near the edges of the igneous rock, the sandstone is discolored and displays a different texture from the rest of the exposure.
• An exposure of sedimentary rock contains pieces of a metamorphic rock that is exposed several miles away.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Select or identify from a collection of potential model components, including distractors, the components needed to model the phenomenon. Components might include different rock types, processes that change</td></tr>
</table>

one rock type into another, surface environments on Earth where these processes occur and where different rock types exist, and layers within Earth where these processes occur. Sources of energy (radiation, convection) that drive the cycling (but *not* the creation of) matter should also be included as components.
2. Assemble or complete, from a collection of potential model components, an illustration, virtual representation of a physical model, or flow chart that is capable of representing how energy (radiation, convection) drives processes that cycle (but do *not* create) matter on Earth. This *does not* include labeling an existing diagram.
3. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to resultin the cycling of Earth's materials.
4. Make predictions about the effects of changes in the rock cycle. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5. Given models or diagrams of the rock cycle, identify different rock types and how they change in each scenario OR identify the properties of energy that cause Earth materials to cycle between different rock types.
6. Identify missing components, relationships, or other limitations of the model that can explain the cycling of Earth's materials.
7. Identify or select the relationships among components of a model that describe the relationship between energy and the cycling of matter that forms different types of rock, or explain the relationship between energy and the cycling of matter that forms different types of rock.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS2-2
Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future.</td><td>ESS2.A: Earth’s Materials and Systems
• The planet’s systems interact over scales that rage from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future.

ESS2.C: The Roles of Water in Earth’s Surface Processes
• Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations.</td><td>Scale, Proportion, and Quantity
• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on how processes change Earth’s surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events.
• Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind.
• Emphasis is on geoscience processes that shape local geographic features, where appropriate.

Content Limits
• Students are expected to know all of the components/processes of the rock cycle but not specific rock or mineral names.
• <u>Students do not need to know</u> Endogenic or exogenic systems, specific intervals of the Geological Time Scale by name, specific volcano types (shield, effusive, composite, etc.)/</td></tr>
<tr><td colspan="4" align="center">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS2-2:
• A hillside in Oregon experiences an intense rain storm. At the end of the storm, part of the hillside collapses, covering a road with mud and debris.
• In Northern Arizona, there is a large circular depression.</td></tr>
</table>

	• In southeastern Pennsylvania, the landscape is dotted with a number of irregular holes that lead to caves. • When viewed from orbit, the Eastern coastline of South America and the Western Coast of Africa look as though they were joined together, similar to a jigsaw puzzle.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.
2. Express or complete a causal chain explaining how a given process(es) acts to modify Earth's surface in the long term and/or short term. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
3. Identify evidence supporting the inference of causation that is expressed in a causal chain for a process(es) that acts to modify Earth's surface in the long term and/or short term.
4. Use an explanation to predict the effect of the process on Earth's surface, given a change in conditions (e.g., atmospheric, tectonic, geological, hydrologic).
5. Describe, identify, and/or select information needed to support an explanation for how processes affect Earth's surface over the short and/or long term.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS2-3
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate motions.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to provide evidence for phenomena.</td><td>ESS1.C: The History of Planet Earth
• Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (secondary)

ESS2.B: Plate Tectonics and Large-Scale System Interactions
• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.</td><td>Patterns
• Patterns in rates of change and other numerical relationships can provide information about natural systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of data include similarities of rock and fossil types on different continents, the shapes of continents (including continental shelves), and the locations of ocean structures (such as ridges fracture zones, and trenches).

Content Limits
• Paleomagnetic anomalies in oceanic and continental crust are not assessed.
• <u>Students do not need to know</u>: Specific chemical makeup of the crust, mantle, and core; specific rocks within major categories (e.g., basalt, amphibolite, granite); mineral crystallization orders (e.g., Bowen's Reaction Series), mineral melt orders.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS2-3:
• There are volcanoes on all of the Hawaiian islands. But only volcanoes on the southeastern most island, Hawaii, are active today.
• Earthquakes are very commonly felt on the islands of Japan.
• The Atlantic coasts of South America and Africa appear to fit together like two jigsaw puzzle pieces. Identical fossils of certain plants and animals are preserved in rocks found along both coasts.
• Earthquakes are very rare in the State of Florida.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Identify patterns or evidence in the data that supports conclusions about how the Earth's plates have moved and interacted with each other (e.g., converged or diverged).*</td></tr>
<tr><td colspan="4">2. Use relationships identified in the data to predict the locations of fossils, earthquakes, or volcanoes.</td></tr>
</table>

3. Illustrate, graph or identify relevant features or data that can be used to identify past plate motions or estimate the rate of change in tectonic processes.
4. Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations.*
5. Compile from given information, the data needed to identify a pattern in the rate of change or evidence of past plate motions.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS2-4
Develop a model to describe how the cycling of water through Earth’s systems is driven by energy from the sun, gravitational forces, and density.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop a model to describe unobservable mechanisms.</td><td>ESS2.C: The Roles of Water in Earth’s Surface Processes
• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
• Global movements of water and its changes in form are propelled by sunlight and gravity.</td><td>Energy and Matter
• Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of models can be conceptual or physical.
• Content emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle.
• Practice emphasis is on developing a model and being able to explain reasoning behind choices made relative to the developing or changing of a model. While a few interactions can be about using the model, the focus should not be on using the model or designing an experiment using the model. Any stand-alone items written to this PE should be centered on the development of models.

Content Limits
• A quantitative understanding of the latent heats of vaporization and fusion is not assessed.
• <u>Students do not need to know</u>:
  o Cloud types
  o Types of aquifers and components of aquifers
  o Concepts of subsurface water flow and transmissivity (e.g., permeability/porosity of the substrate and interactions with fluids; behaviors of subsurface fluids under confinement (both quantitatively and qualitatively).</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS2-4:
• When driving over a bridge on a cool morning, you see fog over the river but not over the land.
• Morning fog and mist soon disappears after the sun rises on a clear day.
• The Blue Mountains have snow that melts (eventually) into the Columbia River to the John Day Dam
• In the Iowa cornfields in the summer, a dense dome of humidity forms over the cornfields.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
</table>

1. Select or identify from a collection of potential model components including distractors, the components needed to model the model of evaporation, condensation, transpiration, precipitation or other behaviors of water molecules during the water cycle.
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing the phenomenon. This <u>does not</u> include labeling an existing diagram.*
3. Manipulate the components of a model to demonstrate the effects those adjustments would have on the behavior of water in the water molecules in the water cycle.*
4. Make predictions about the effects of changes to the parts of the model. Predictions can be based on manipulating model components, completing illustrations, or selecting from a list with distractors.
5. Identify missing components, relationships, or other limitations of the model.
6. Describe, select, or identify the relationships among components of a model that describe or explains the phenomenon.
7. Identify, describe or explain reasons for choosing components of a model of the water cycle.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS2-5
Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.</td></tr>
<tr><td>Dimensions</td><td>Planning and Carrying Out Investigations
• Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.</td><td>ESS2.C: The Roles of Water in Earth’s Surface Processes
• The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

ESS2.D: Weather and Climate
• Because these patterns are so complex, weather can only be predicted probabilistically.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed system.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide.
• Emphasis is on how weather can be predicted within probabilistic ranges.
• Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as condensation).

Content Limits
• Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.
• Weather incidents internal to air masses are excluded because the focus is on the interfaces between large scale air masses.
• <u>Students do not need to know</u>: Names of the various types of clouds, weather symbols used on weather maps, weather symbols used on reports from weather stations. A legend will be included on weather maps.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS2-5:
• One fall day starts out warm and fairly still. The wind picks up and the temperature drops and it begins to rain.
• The flag outside a school has been resting against the flagpole, unmoving all morning. In the early afternoon, it starts flapping in the wind. At sunset, rain begins.
• Fall days were chilly, then the temperature warmed up for a few days.
• A tornado formed in the Pacific Ocean near Oregon.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.	
Task Demands	
1. Evaluate the sufficiency and limitations of data collected to explain the phenomenon.	
2. Identify the outcome data that should be collected in an investigation of the interactions of air masses and the resulting changes in weather conditions.	
3. Make and/or record observations about the interactions of air masses and/or the relationships between those interactions and patterns of weather in a particular location.	
4. Describe, illustrate, or select tools, locations, and/or methods to use in investigations of phenomena related to interactions of air masses. This should show how or where measurements will be taken.	
5. Identify, select, or describe the relevance of particular data or sources relevant to the process of weather forecasting.	
6. Predict the effects of given changes in the air masses' interactions on subsequent weather.	
7. Identify or specify inferences supported by data collected.	

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS ESS2-6
Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe phenomena.</td><td>ESS2.C: The Roles of Water in Earth’s Surface Processes
• Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

ESS2.D: Weather and Climate
• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
• The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.</td><td>Systems and System Models
• Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution.
• Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis Effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis Effect and the outlines of continents.
• Examples of models can be diagrams, maps and globes, or digital representations.

Content Limits
• Assessment does not include the dynamics of the Coriolis effect.
• <u>Students do not need to know</u>: names of specific winds, different cloud types (cumulus, cirrus etc.), names of specific ocean currents, or perform any quantitative analyses based on the Coriolis Effect, mathematical calculations beyond trends, or measurements of central tendency.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS2-6:
• In December 2010, Gary, Indiana, on the southeast shores of Lake Michigan, had approximately 30 inches of snow over a three-day period, whereas Chicago, Illinois, 30 miles away, received barely any snow.</td></tr>
</table>

	• Onshore and offshore breezes—in the morning, the breeze comes in from the ocean. At night, the breeze is blowing in the opposite direction. • Wind storms in the Sahara become hurricanes that affect the east coast of North America and the Caribbean, but not the coast of South America. • The Westerlies vs. The Easterlies and the trade winds—why are these wind patterns banded as you move north from the equator?

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Select or identify from a collection of potential model components, including distractors, components needed for a model that can explain the effect of unequal heating of Earth's surface. Components might include oceans, land forms, wind currents, ocean currents, energy flows, upwelling, downwelling, water temperature, air temperature, and salinity.
2. Assemble or complete an illustration or flow chart that is capable of representing the effect of unequal heating of Earth's systems on atmospheric and oceanic circulation. Key components of the model might include: oceans, land forms, wind current, ocean current, energy flows, upwelling, downwelling, water temperature, and salinity.
3. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to result in a phenomenon.
4. Make predictions about the effects of changes in temperature on a phenomenon. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors. Make predictions about the effects of changes in water temperature or density, distance from the lake, location, etc.
5. Identify missing components, relationships, or other limitations of a model.
6. Describe, select, or identify the relationships among components of a model that explain the effect of unequal heating of Earth's systems on atmospheric and oceanic circulation.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS3-1
Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td><td>ESS3.A: Natural Resources
• Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.</td><td>Cause and Effect
• Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans.
• Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (location of the burial of organic marine sediments and subsequent geologic traps), metal ores (location of past volcanic and hydrothermal activity associated with subduction zones), and soil (location of active weathering and/or deposition of rock).</td></tr>
<tr><td colspan="4" align="center">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS3-1:
• Large surface deposits of sand and gravel are much more common in Massachusetts than they are in Virginia.
• Diamonds are found on the ground in a State Park in southwestern Arkansas.
• Bauxite, an Aluminum ore, and fossil tree roots are found in an exposure in Queensland, Australia.
• A well is drilled and water is discovered near Colorado Springs, CO. Ten miles to the Southwest, another well is drilled to the same depth and no water is discovered.</td></tr>
<tr><td colspan="4" align="center">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4" align="center">Task Demands</td></tr>
<tr><td colspan="4">1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.</td></tr>
<tr><td colspan="4">2. Express or complete a causal chain explaining that the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause-and-effect chains.</td></tr>
</table>

3. Identify evidence supporting the inference of causation that is expressed in a causal chain.
4. Use an explanation to predict the distribution of Earth’s mineral, energy, or groundwater resources, given a change in current geoscience processes.
5. Describe, identify, and/or select information needed to support an explanation.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS3-2
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to determine similarities and differences in findings.</td><td>ESS3.B: Natural Hazards
• Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.</td><td>Patterns
• Graphs, charts, and images can be used to identify patterns in data.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable.
• Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods).
• Examples of data can include the locations, magnitudes, and frequencies of the natural hazards.
• Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

Content Limits
• Analysis may include recognizing patterns in data, identifying periodicity, straightforward mathematical comparisons (more, less, faster, slower), examining trends, looking for differences in tabular data, qualitative spatial analysis (e.g., looking at fault lines), recognizing trends and patterns. May include drawing lines of best fit and extrapolating from those lines.
• Analysis should not include regression analysis or calculating correlations.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">For this performance expectation, the phenomena are sets of data. Those are the observed facts that the kids will look at to discover patterns. Below, we enumerate some of the patterns that might comprise the data sets (phenomena) to be analyzed.

Patterns that describe the data sets for MS-ESS3-2:
• A sequence of maps illustrates temperature patterns and occurrence of tornados over the course of the year (to identify variations of tornado risk across regions and also to identify more proximate predictors of tornados).</td></tr>
</table>

	• A sequence of maps illustrates temperature and humidity patterns and occurrence of hurricanes over the course of the year (to identify variations of hurricane risk across regions and also to identify more proximate predictors of hurricanes). • Temperature and humidity patterns in the Pacific Ocean can be correlated to the snow pack on Mt. Hood. • A map of average snowfall in the Great Lakes region shows more snow has fallen in locations nearer to the lakes. Data include surface temperatures, water temperature, wind patterns and snowfall.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Organize/Arrange data to highlight patterns, trends, or correlations between natural hazards and geologic/atmospheric events that occur before a natural hazard.*
2. Tabulate/Graph data to highlight patterns, trends, or correlations between natural hazards and geologic/atmospheric events that occur before a natural hazard.*
3. Use relationships identified in the data to predict natural hazards.
4. Illustrate or describe patterns over time that can be used to predict natural hazards.*
5. Identify human and societal responses designed to mitigate catastrophic natural hazards.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS3-3
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Apply scientific principles to design an object, tool, process or system.</td><td>ESS3.C: Human Impacts on Earths Systems
• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts of Earth unless the activities and technologies involved are engineered otherwise.</td><td>Cause and Effect
• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact.
• Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the constructions of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as air, water, or land).

Content Limits
• Students will not describe the relationship between natural resources and sustainability</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Engineering performance expectations are built around meaningful design problems rather than phenomena.

Some example design problems for MS-ESS3-3:
• Nurdles are small plastic pellets, smaller than a pea. Billions of them are used in creating plastic products. Many fall out of the truck or ship container that they are transported in and end up in oceans where they are mistaken as food by marine animals.
• Glen Canyon Dam is located on the Arizona and behind it sits Lake Powell the second largest reservoir in the United States. Glen Canyon Dam holds back sediment that would naturally replenish downstream ecosystems. The sediment that is trapped behind the dam is filling Lake Powell at a rate of roughly 100 million tons of sediment a year, decreasing the dam's ability to store water.</td></tr>
</table>

	• Farmers in Iowa plow their fields in the spring in order to break up the thick soil and disrupt weeds from growing. The practice of plowing however, causes farmers to lose valuable top soil due to wind erosion. • In the central North Pacific Ocean there is what is described as a great garbage patch. This large area has high concentrations of plastics, fishing nets, and other debris. This debris is sometimes mistaken as food by marine animals.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Identify or assemble from a collection, including distractors, the relevant aspects of human impact on the environment that given design solutions, if implemented, will resolve/improve.
2. Using the given information about human impact on the environment, select or identify the criteria against which the device or solution should be judged.
3. Using given information about human impact on the environment, select or identify constraints that the device or solution must meet.
4. Using given data, propose/illustrate/assemble a potential device (prototype) or solution to monitor and/or minimize human impact on the environment.
5. Using a simulator, test a proposed prototype and evaluate the outcomes, potentially including proposing and testing modifications to the prototype.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS3-4
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td><td>ESS3.C: Human Impacts on Earth Systems
• Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources such as fresh water, minerals, and energy sources.
• Examples of impacts can include changes to the appearance, composition, and structure of Earth’s systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

Content Limits
• Assessment is limited to one form of consumption and its associated impacts.
• <u>Students do not need to know</u>: mechanisms or details about interior geological processes, quantities and types of pollution released, changes to biomass and species diversity, or changes in land surface use.</td></tr>
<tr><td colspan="4" align="center">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS3-4:
• Lake Urmia in Iran was once the nation’s largest lake. Today, the lake is 5% as large as it used to be.
• In 1990, much of the tropical rain forests on the Hainan Island were clear-cut to obtain wood, and to create space for plantations. Today, the forests are still smaller and less developed than they were before 1990.
• A coal power plant in Martins Lake, Texas, releases huge clouds of gas into the air every day.
• The open-pit copper mine Ok Tedi Mine in Papua, New Guinea, releases its drainage nearby. Downstream, the rivers turned orange and the fish died.</td></tr>
<tr><td colspan="4" align="center">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4" align="center">Task Demands</td></tr>
</table>

1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information.
2. Predict outcomes when properties or amounts of consumption are changed, given the inferred cause and effect relationships.
3. Describe, identify, and/or select information needed to support an explanation of how increases in human population and per-capita consumption of natural resources impact Earth's systems.
4. Identify patterns or evidence in the data that support conclusions about the relationship between per capita consumption and limited natural resources.*
5. Using evidence, explain the relationship between per capita consumption and limited natural resources.*
6. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to result in the phenomenon.*

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS3-5
Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.</td></tr>
<tr><td>Dimensions</td><td>Asking Questions and Defining Problems
• Ask questions to identify and clarify evidence of an argument.</td><td>ESS3.D: Global Climate Change
• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as the understanding of human behavior and on applying that knowledge wisely in decisions and activities.</td><td>Stability and Change
• Stability might be disturbed either by sudden events or gradual changes that accumulate over time.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of factors include human activities (such as fossil-fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity).
• Examples of evidence can include tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS3-5:
• A region in the Saint Elias Mountains in Alaska used to be covered by Plateau Glacier. It is now populated with thick vegetation and lake.
• On December 14th, 2016, the Deely Power Plant was operating. Its chimney emitted a large cloud of white smoke.
• The Solomon Islands are a group of small islands located in the Pacific Ocean. Five of these islands disappeared in 2016.
• Mount Etna, one of the world's most active volcanoes, erupted in May 2016, delivering large plumes of smoke that filled the horizon.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Organize and/or arrange (e.g., using illustrations and/or labels) or summarize data to highlight trends, patterns, or correlations.</td></tr>
<tr><td colspan="4">2. Generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations relating to climate change. This may include sorting out distractors.</td></tr>
<tr><td colspan="4">3. Express or complete a causal chain explaining the effects that climate change has on the environment. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram or completing cause-and-effect chains.</td></tr>
</table>

4. Compile, from given information, the particular data needed for a particular inference about the relationship between greenhouse gas emissions and rising global temperatures. This can include sorting out the relevant data from the given information.
5. Describe, select, or identify the relationships among components of a model that describe the mechanism of rising global temperatures, or explain the consequences of rising global temperatures.
6. Select, from a list of potential hypotheses including distractors, either the testable hypothesis from untestable hypotheses or the best hypothesis to clarify evidence relating to climate change.
7. Construct or assemble a valid hypothesis that clarifies evidence relating to climate change.
8. Select from a list of questions, including distractors, about the relationships among the data that either support or contradict a hypothesis or to clarify data that describe the mechanism of rising global temperatures, or explain the consequences of rising global temperatures.
9. Ask questions to obtain or clarify information related to the rise of global temperatures in the past century.